



**SUPERIOR MODELS
THEIR OPERATION
AND CARE**

Second Edition

**General Motors Export Company
224 West 57th Street
New York, New York
U. S. A.**



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A WORD TO THE CAR OWNER

THE increasing use of motor vehicles in places far removed from repair shops, or even expert advice, has clearly demonstrated the great need for complete, carefully planned instruction books, books that adequately cover the routine matters of car operation and care, and also the more involved adjustments and repairs, ordinarily not discussed. The city motorist has also been demanding a book of this character; and in presenting this departure from the former type of instruction book it is hoped the wants of both classes of motorists are met.

The degree of success encountered in the use of a motor car—regardless of price or kind—is a direct result of and in direct proportion to the thought and effort expended in caring for that car; it therefore rests with the car owner to do the things recommended, or to see that they are done. In this respect, it is imperative that one fact be continually borne in mind: The motor car is essentially a piece of machinery; even more than this—it is a piece of very fine machinery, one that is often subjected to services for which it was not designed; it is only the great factors of safety incorporated in motor car design that save it from destruction.

Like any other piece of machinery however crude or fine, the motor car requires certain care along certain well established lines at certain definitely fixed intervals; given this care, reliability at all times is assured. Nowhere is the adage a stitch in time saves nine more significant or pregnant with meaning than with respect to a motor car. So true is this that careful attention to the details of routine care is to a motor car what preventive medicine is to protection against disease; in short, it is an absolute necessity.

Fortunately, the amount of labor to care properly for a car is not great; it is in fact far less than one would think. Even so small a period as one hour a week of conscientious, intelligent effort by the owner-driver, or his chauffeur, will secure the results both he and the car manufacturer desire—and can have.

In compiling this book and in placing it in the hands of the car owner it is not intended that it shall be regarded as a cure-all for, or an encyclopedia of, motor car ills. Rather should it be regarded as operating to prevent these ills by applying common sense methods to the care and operation of the car.

It is suggested that the car owner first familiarize himself with the contents of the book and then make a careful study of the parts devoted to the driving of the car and its routine care. He will find a very serious attempt has been made to detail when and how and with what to carry out these operations. Let his efforts, then, be in keeping with what the manufacturer has done and thereby ensure his retaining what he buys—a satisfactory car.

The manufacturer has already done his part; the distributor has shared the responsibility by delivering the car in first class condition and stands ready with expert service; the balance rests with the car owner, for in the final analysis it is he that is the master of his car's fate.

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PART ONE

SOME SUGGESTIONS ON DRIVING and OTHER MATTERS

IT IS USUALLY BOTH UNNECESSARY AND UNWISE TO DRIVE AT TOP SPEED. CAREFUL DRIVING IS ECONOMICAL, SAFE, COMFORTABLE DRIVING.

REMEMBER YOUR FELLOW MOTORIST. HIS RIGHTS TO THE ROAD ARE EQUAL TO YOURS. AND DON'T EVER FORGET HE DOES NOT KNOW WHAT YOU ARE GOING TO DO; PROTECT YOURSELF BY NOT TAKING IT FOR GRANTED THAT HE WILL ALWAYS DO THE RIGHT THING.

CHAPTER I

THINGS TO DO ON RECEIVING THE CAR

Most factories in preparing a motor car for shipment drain the cooling and fuel systems, and sometimes even the engine lubricating system, also. A final examination of the car and its equipment is also made, during which every care is taken to ensure each item being in accordance with specifications.

Despite these efforts, however, many things happen to a car and its equipment in the course of a long journey from the factory. It is necessary, therefore, that the buyer, to safeguard his own interests on receiving the car, observe certain precautions with respect to the above mentioned matters.

It often happens that a car is delivered to the buyer ready for use. In such a case, matters are greatly simplified so far as personal labor of the buyer is concerned, but it is still highly desirable for him, for his own protection, thoroughly to inspect the car, its components, and equipment before putting it into service. If the car is to be run any distance—for example, from the distributor's place of business to the owner's residence, he may well go over the car personally with the distributor.

Lest the buyer feel the manufacturer is emphasizing this period of a car's life in a manner disproportionate to its true value, let him remember that the importance of this period, as well as that of the first 1,000 miles (1,500 km.) of use, can not be too strongly emphasized. The treatment and care a car receives during these two periods determine with unfailing accuracy its condition when it will have run 10,000 miles (15,000 km.) as no other things, or series of things, can.

Equipment—First, examine the car and its equipment. See that the proper complement of tools is present; that the circulars pertaining to the various accessories are included; that the extra demountable rim or spare wire wheel, tyres, etc., are on hand; that the various lamps are complete and in working order; in short, that all specified equipment has been delivered. See that the car and engine numbers correspond to those in the distributor's bill of sale or contract.

Tyres—Examine the tyres and note whether the air pressure is at the required figure (see chapter XVII, part three); if a spare tyre is included in the car's equipment, see that it, too, is fully inflated.

Water, Fuel, Oil—Open the fuel shut-off cock between the vacuum tank and the carburetor; the cock is open when its handle is turned down—toward the ground. Fill the fuel tank. Fill the oil pan to the proper level, as shown on the oil level gauge (see fig. 5). Fill the radiator with **clean** water; after the engine has run a few minutes, it may be possible to add more water. (See chapter III, part one, for oil, grease, fuel, and water specifications.)

Examine the gear box and rear axle to ascertain if the oil in these parts is at the level of the filler plug holes; if below this level, add sufficient oil to bring it to the proper height.

Grease—Fill all lubricators with grease (see fig. 4 for their locations). Remove the hub caps from the front wheels and see that there is sufficient grease present; the bearings should be well covered with grease and the hub caps quite full. **Securely replace the hub caps.**

Storage Battery—Examine the storage battery to see that the electrolyte is at the right level and test the electrolyte with a hydrometer to determine if it is of the proper density, i. e., whether the battery is fully charged (see chapter XV, part three, for details).

It is good practice at this time to give the storage battery a freshening charge—i. e., to charge it for a short time, so as to increase the specific gravity of the electrolyte to 1.280 to 1.300.

It is important to make certain the storage battery is firmly clamped in place, as a loose battery is easily injured by the severe jolting it is subjected to when the car is in motion.

Battery Cables—The battery cables (heavy wires) should be firmly attached to their respective terminals on the battery; if corrosion is noticed, in which case the terminals will be a bright green and covered with a whitish salt, disconnect the cables and thoroughly clean them and the terminals, and then securely reconnect them (see chapter XV, part three, for details).

License Data—Data on horsepower, size of engine, wheelbase, etc., will be found in chapter II, part four.

Before undertaking any operation on your car, be absolutely certain you know how to handle that operation; if you are in any degree uncertain, study the details of that operation before attempting any part of it.

Before lubricating any part of your car, thoroughly remove all dirt or other foreign matter from the lubricators, filler caps, or plugs, to prevent the lubricant from carrying such dirt or foreign matter into the part you wish to lubricate; clean the fuel tank filler cap before removing it when filling with fuel.

CHAPTER II

SUGGESTIONS ON DRIVING

Before attempting to start the engine of a new car, or one that has been out of service for any protracted period, see that fuel is in the carburetor.

Starting the Engine—1. Before starting the engine, set the hand brake by pulling back on the hand lever as far as it will easily go. Next, see that the gearshift lever is in the neutral position, i. e., in that position in which it can be readily moved from side to side but not from front to rear.

2. Move the spark and throttle hand levers to the starting position (Left, fig. 1).

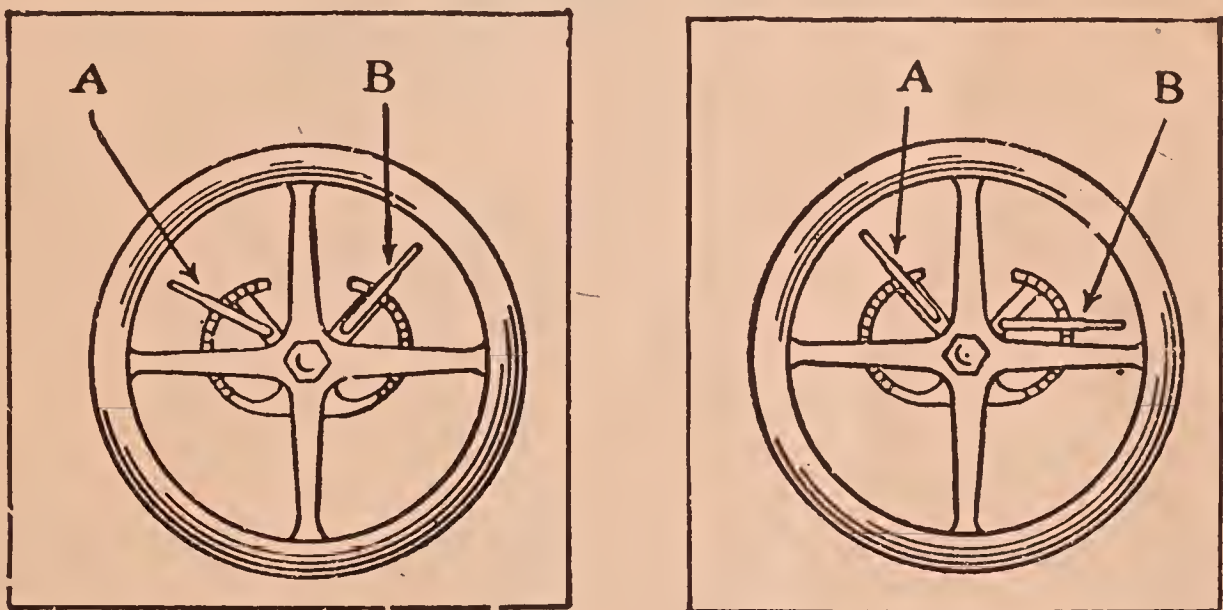


Fig. 1

Left—Starting Position of Spark and Throttle Levers
Right—Running Position of Spark and Throttle Levers

A. Throttle hand lever

B. Spark hand lever

3. Pull the carburetor choke rod nearly all the way out (see page 11).

4. Turn on the ignition by inserting the key into the ignition switch, pressing in on it and turning it one-quarter to the left or right.

5. Firmly press down on the starting button with the foot, holding it thus for twenty to thirty seconds, when the engine should start. Immediately release the button, and do not again press it whilst the engine is in operation

If the engine should not start, release the starting button and note whether the controls are in their proper position; if all appear in order, try again, using the starter as directed above. Should the engine still fail to start, see chapters I, XIII, XIV, XV, and XVI, part three, for causes and remedies.

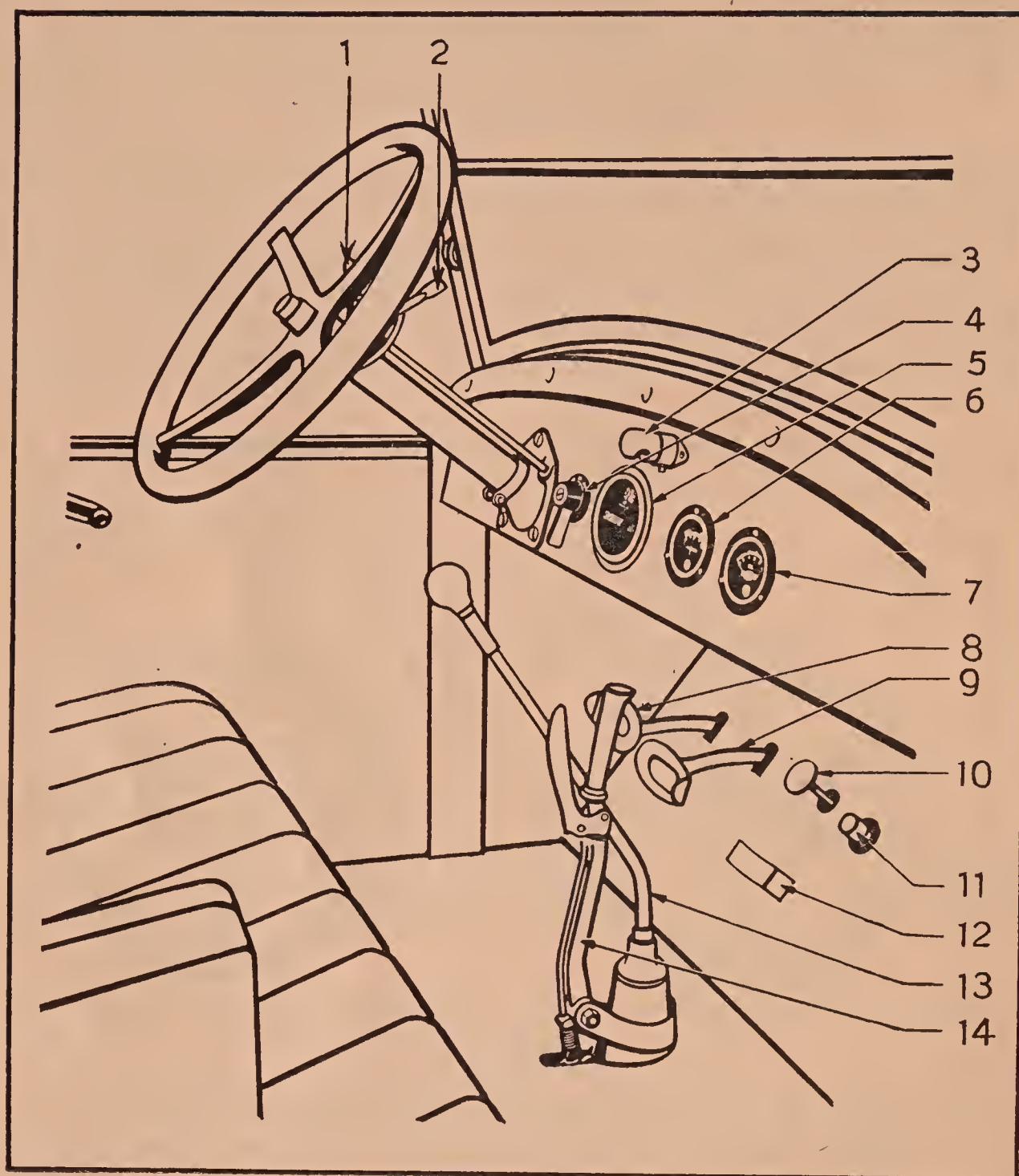


Fig. 2. Driving Compartment

- | | |
|--------------------------------|----------------------|
| 1 Throttle hand lever | 7 Oil pressure gauge |
| 2 Spark hand lever | 8 Clutch pedal |
| 3 Instrument-lamp | 9 Brake pedal |
| 4 Ignition and lighting switch | 10 Accelerator pedal |
| 5 Speedometer | 11 Starter pedal |
| 6 Ammeter | 12 Foot rest |
| | 13 Gearshift lever |
| 14 Brake hand lever | |

Hand Cranking—In certain cases, as when there is no storage battery in the car or because the starter does not operate properly, it may be necessary to use the starting crank to start the engine. Set the carburetor choke, ignition switch, and spark and throttle levers as above. Insert the starting crank into the opening in the dust shield beneath the radiator, pushing in on it and turning it until the starter jaws engage, and then sharply pull up. Unless the person

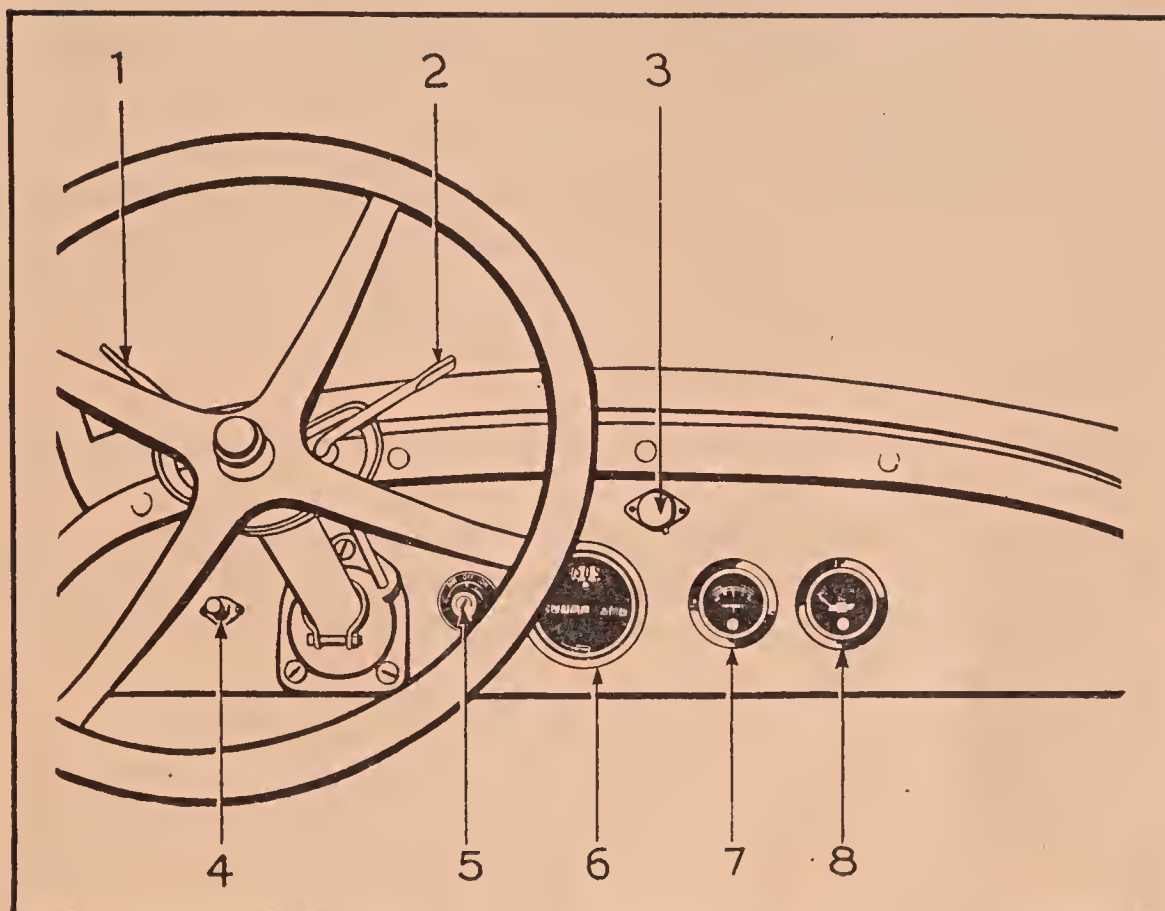


Fig. 3. Instrument Board

- | | |
|-----------------------|--------------------------------|
| 1 Throttle hand lever | 5 Ignition and lighting switch |
| 2 Spark hand lever | 6 Speedometer |
| 3 Instrument-lamp | 7 Ammeter |
| 4 Carburetor choke | 8 Oil pressure gauge |

carrying out this operation is thoroughly experienced in hand-cranking an engine, he should under no circumstances push down on the starting crank, as serious personal injury might result. **Remove the starting crank after starting the engine.**

Cold Weather Starting—A cold engine requires a richer mixture, both for starting and running, than a warm or a hot one; moreover, an engine heats more rapidly with such a mixture. It is necessary, therefore, in starting a cold engine, to pull out the carburetor choke rod a distance proportionate to the degree of cold. Moderately low temperatures require that the choke rod be pulled out only part way, whilst a lower one is met by pulling the choke rod as far out as it will come. This latter position, however, must be most judiciously used, because then practically all the carburetor air supply is shut off; the choke rod should therefore be slightly pushed in after the engine has been cranked a few revolutions to obviate the possibility of too rich a mixture, which would prevent ready starting. It is best, when starting in very low temperatures, to keep moving the choke rod all the way out and partly in whilst the engine is being cranked, thus preventing the accumulation of unvaporized fuel in the inlet manifold and cylinders.

A cold engine requires a rich mixture for starting; a hot engine, a lean one.

Carburetor Choke Running Position—As soon as the engine has started, push the choke rod in, though not enough to cause back-firing or materially to reduce its speed. Pushing the choke rod in produces a lean mixture and may cause the engine to stop running, or, at best, to run with but little power. The choke rod, therefore, should be pulled out a certain distance and the engine run until it is well heated, when it should be pushed all the way in. See chapter XIII, part three—**Carburetor Air Regulator, Adjustment of the Carburetor, and Formation of Carbon**; and chapter XII, part three—**Crankcase Dilution**.

Position of the Spark and Throttle Hand Levers—As soon as the engine has started, immediately remove the foot from the starting button and move the spark and throttle hand levers to the running position (Right, fig. 1) their normal positions when the engine is in operation. **Do not let the engine race—run at a high rate of speed, as this is injurious to a degree.**

Accelerator and Throttle Hand Lever—Variations of the engine speed—and therefore of its power—are obtained by means of a throttle valve in the carburetor, the control of this valve being incorporated in both the accelerator and the throttle hand lever. The normal position of the accelerator is that of the closed throttle, being held in this position by a spring; hence, when the accelerator is relieved of foot pressure, the throttle automatically closes.

The function of the throttle hand lever (A, fig. 1) is to limit the minimum speed of the engine and also to vary the engine speed through its entire range. The car can be driven, that is, its speed controlled, by manipulation of either the throttle hand lever or the accelerator, but the driver will find use of the latter more convenient, as it leaves both hands free for steering and other things. During long and uninterrupted running on high gear, however, it may prove more comfortable to use the throttle hand lever and thus prevent tiring the foot and ankle; its use when passing over stretches of rough road, also, is advantageous in that it makes possible control of the engine speed, and hence of the car speed, at a steady rate.

Spark Hand Lever—The spark hand lever's (B, fig. 1) function is to vary the point at which ignition occurs in the cylinders; manipulation of this part advances or retards the ignition (makes it late or early) as may be desired by the driver.

The best position for the spark hand lever is that point **slightly beyond which** the engine will pound or pink. As a general rule, the spark should at all times be kept as far advanced as possible—even when the engine is idling (throttled down), but not to the extent of causing the engine to pound or labor through the ignition being advanced too far. A well advanced spark makes for, in conjunction with the throttle, maximum speed and power and coolest running; a retarded spark makes for the least speed and power, an overheated engine, increased fuel consumption, rapid carbon formation—in short, high operating costs

Oil Pump—As soon as the engine has started, slightly increase its speed to ascertain if the lubrication system is functioning properly, and then close the throttle to the idling position. If no or little pressure—not less than 2 pounds (0.14 kg.) is the correct figure—is shown on the oil pressure gauge, it may be taken as evidence of improper action of the lubrication system, and **the engine should be immediately stopped to determine the cause.**

Driving—It is suggested that before attempting to drive the car on a road the novice study and practice the various movements involved in gear-shifting and in clutch and brake manipulation, as well as those of the spark and accelerator controls, with the engine running but the car at rest.

This paradox is simple of accomplishment. Jack up one or both rear wheels of the car, taking care thoroughly to block both front and rear sides of each front wheel, using heavy stones or wooden blocks for the purpose; it is essential that the rear axle be prevented from slipping off the jack, as might happen when the rear wheels are rotating. Jacking up one or both rear wheels in this manner permits running the engine and driving the rear wheels and is therefore a simulation of conditions encountered whilst actually driving the car on a road. (The differential—a part of the rear axle mechanism—makes this possible; see chapter V, part three.)

Shifting the Gears—The novice should take his place in the driver's seat and familiarize himself with the position and manipulation of the various control members, actuating them (with the engine at rest) until he has secured a certain degree of familiarity with their location and movement. At this period of his experience he should not work the controls with a view to his possible actions when confronted with any particular emergency he may have in mind, but rather in the light of merely acquainting himself with their positions and movements with relation to his own.

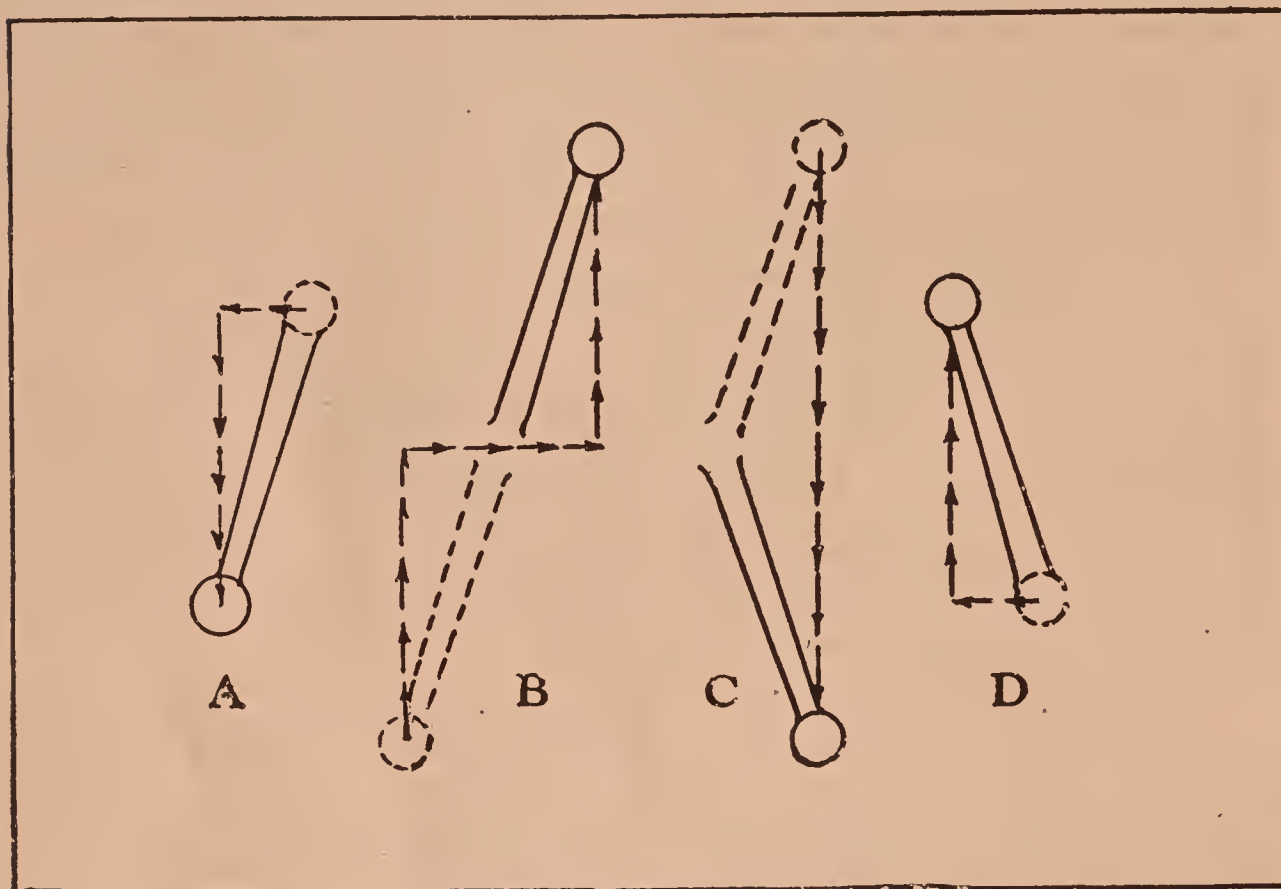
See that the gearshift lever is in the neutral position. Start the engine and allow it to run until it is well heated. Do not forget to push in the choke rod as soon as possible.

Release the hand brake by pulling back on the lever, at the same time pressing in the latch in its upper end, and then, holding the latch thus, pushing the brake lever as far forward as it will go.

First Speed—Disengage the clutch—the large, left hand pedal—by pushing it forward with the left foot as far as it will go. Wait five or ten seconds and then, firmly and steadily, move the gearshift lever as far to the left and then to the rear as it will go—to the first or low speed position.

If difficulty is experienced in moving the gearshift lever into first speed, shift it back to neutral and engage the clutch by gently releasing the pressure on it. This will cause the transmission gears to rotate and thus facilitate meshing the teeth of the gears you have been trying to shift. Disengage the clutch as before and shift to the first speed position—to the left and back; in all probability no difficulty will be experienced, due to the now changed positions of the gear teeth.

Slowly and gently engage the clutch, at the same time very slightly pressing on the accelerator with the right foot to increase the speed of the engine. Power is now being transmitted from the engine to the rear wheels; and were they on the ground instead of jacked up, the car would move ahead. Increase the speed of the engine by adding to the pressure on the accelerator.



Gearshift Diagram

A First speed
B Second speed

C High speed
D Reverse

Second Speed—The next step—that of shifting into second or intermediate speed—should be carried out firmly and without any hesitation. Release the pressure on the accelerator, so that the engine will not race. Disengage the clutch and quickly move the gearshift lever from first speed to second: forward, to the right, and then as far forward as it will go. The movement should be positive and fairly quick, with no hesitation at any point, otherwise the gears will grind (a destructive condition, and one to be avoided whenever possible).

As soon as the gearshift lever is in the second speed position, engage the clutch, letting it come back gently, but more quickly than in first speed, and then slightly speed up the engine by pressing down on the accelerator.

Third Speed—Third speed (top gear) is obtained in the same manner as second. Release the accelerator; throw out the clutch; pull the gearshift lever straight back into third speed; gently but rapidly engage the clutch; then increase the speed of the engine to the desired amount, as shown on the speedometer, by pressing down on the accelerator—say, to fifteen miles (25 km.) an hour.

Shifting Down—Shifting down is accomplished in a similar fashion, though the movements of the gearshift lever are reversed; moreover, the shifts are more rapidly made than when shifting up. Care must be taken, however, in shifting from third to second, and particularly from second to first, that the speed of the rear wheels (actually, the speed of the car) be reduced, otherwise the gears will be badly ground.

APPROXIMATE CAR SPEEDS AT WHICH TO SHIFT GEARS

Shifting up:	First to second.....	5 miles an hour (8 km.)
	Second to third.....	8-12 miles an hour (12-18 km.)
Shifting down:	Third to second.....	15 miles an hour (25 km.)
	Second to first.....	4-2 miles an hour (7-3 km.)

Reverse—Shifting into reverse is accomplished in precisely the same manner as shifting into first—to the left and then forward, but **under no circumstances should this be attempted whilst the rear wheels are turning (the car moving ahead)**, or the transmission will be badly damaged.

Practice—Practice shifting the gears—from first to second and second to third, and then back to neutral, not forgetting to try the reverse speed occasionally, also. Get accustomed to the interrelation of the clutch and gearshift lever movements and of the accelerator.

Don't look at the levers or pedals; in any event, you can't see them on a dark night, so be guided only by the sense of touch. Let some one talk to you; carry on a conversation on a subject far removed from the one in hand; in this manner one can quickly learn to handle the various controls subconsciously—the ideal to strive for. Then, when you feel equal to it, try out your driving ability on the road, but choose one comparatively free from traffic.

 **Slipping the Clutch**—Many people are prone to slip the clutch, particularly when attempting to climb a steep hill on top gear. This practice should be avoided as much as possible because it promotes rapid wear of the clutch lining and causes it to become hard and glazed, resulting eventually in a harsh clutch; wear of the clutch release bearing occurs, also, thus aggravating this disagreeable condition. Slipping the clutch to avoid changing into a lower gear is poor driving; better hill climbing and improved economy and longer life of all parts of the car are always possible through judicious use of the various gears.

Riding the Clutch—The practice of riding the clutch—driving with the left foot resting on the clutch pedal—is likewise bad; see page 73 for further remarks on this subject.

Stopping the Car—The car is stopped by application of the brakes, but it is possible to stop, or at least to retard its speed, by other means. The foot brake—the large right hand pedal—is most frequently used, not because it is more powerful but because it is more convenient; the hand brake is employed mainly when it is desired to hold the car for a long period at a standstill.

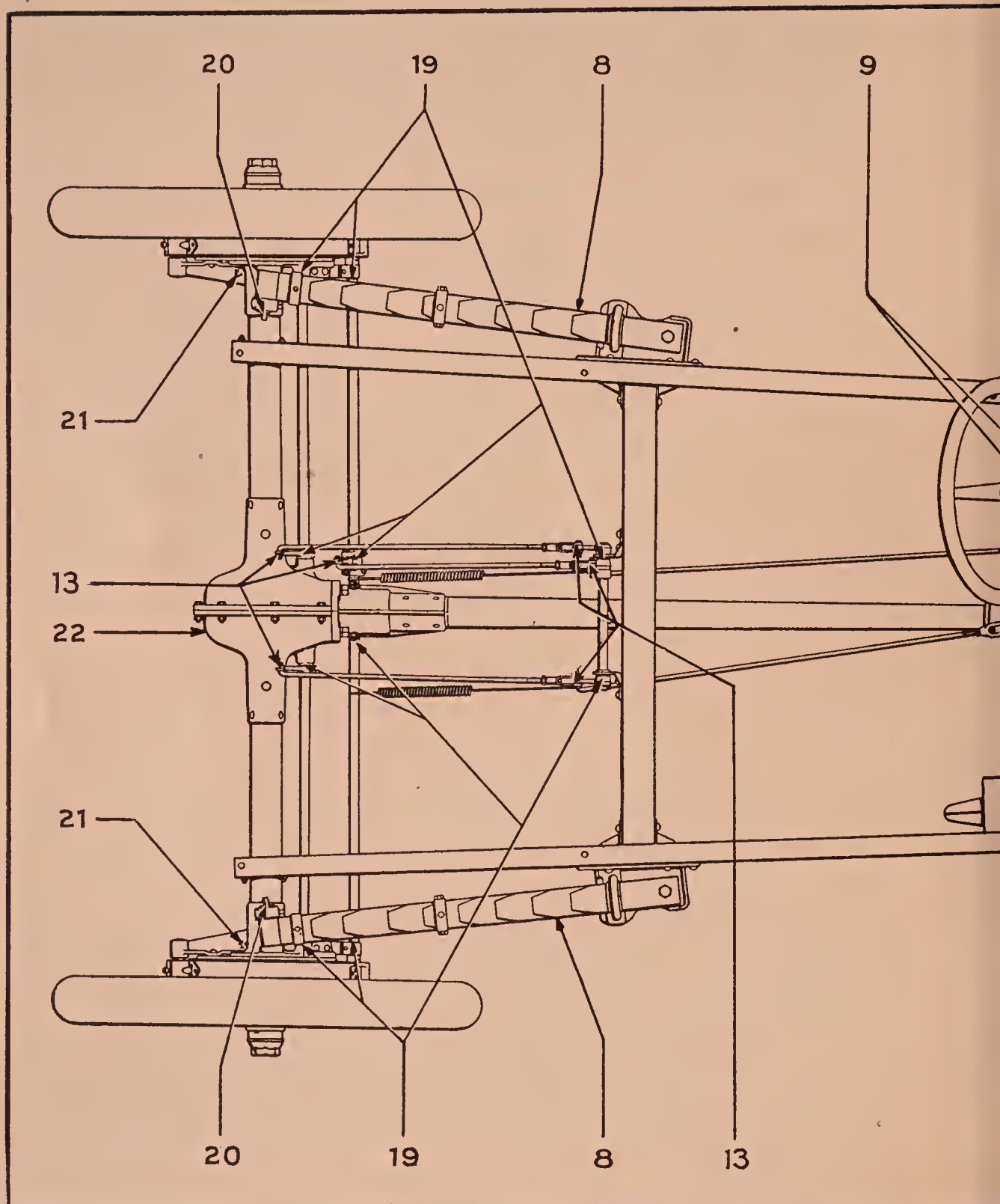
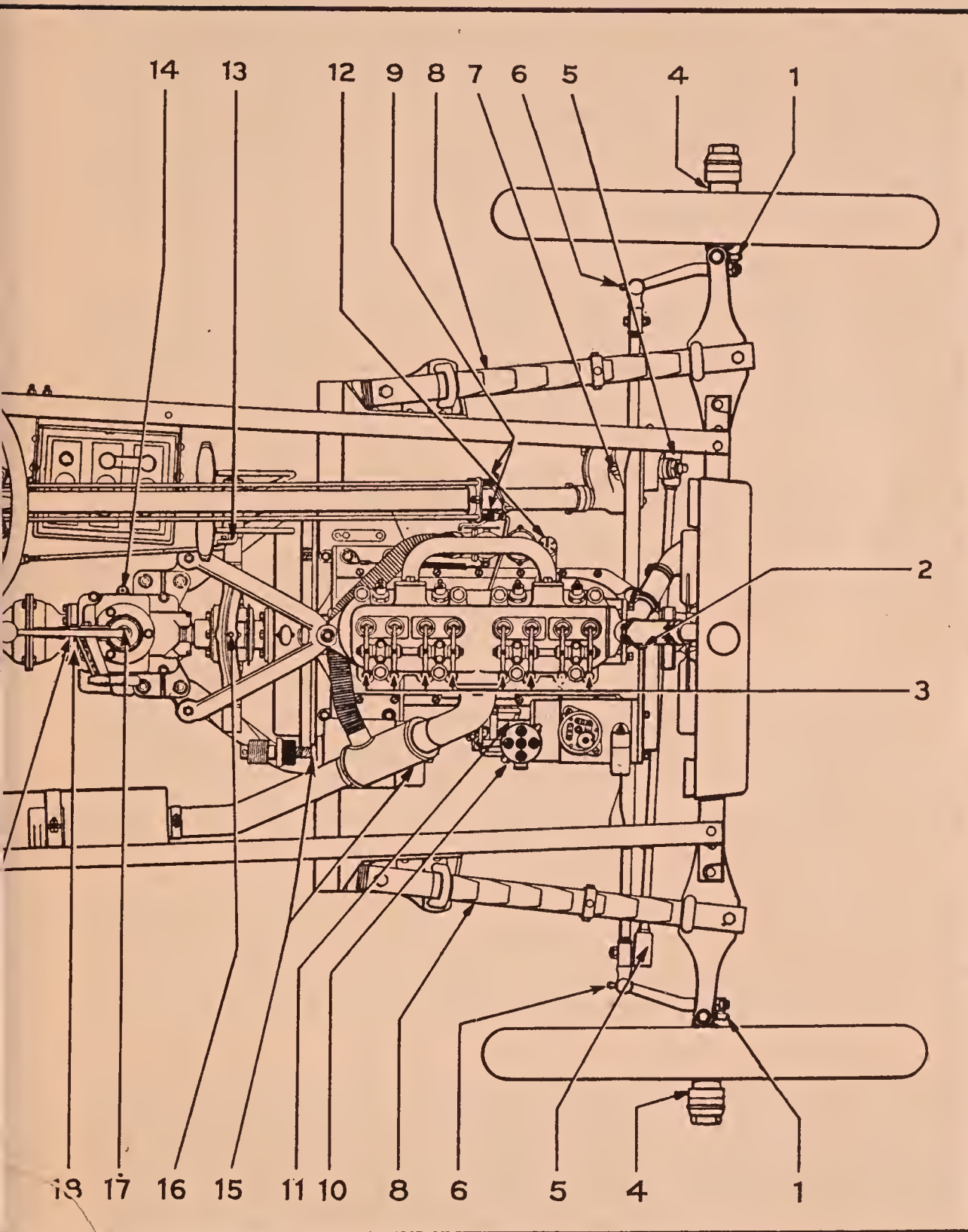


Fig. 4. Points

- | | |
|----------------------------|---------------------------|
| 1 Steering knuckle pivots. | 6 Steering knuckle tie- |
| 2 Water pump and fan | rod pins |
| shaft | 7 Steering gear |
| 3 Valve rockers | 8 Spring leaves |
| 4 Front wheel bearings | 9 Spark and throttle con- |
| 5 Steering gear connect- | trols |
| ing rod | 10 Ignition distributor |
| | shaft |



lubricate

- | | |
|----------------------------|-----------------------------|
| 11 Generator rear bearing. | 17 Gearshift lever bearing |
| 12 Engine oil filler | 18 Brake hand lever bearing |
| 13 Brake rod-ends | 19 Brake shaft bearings |
| 14 Transmission oil filler | 20 Rear spring bushings |
| 15 Starter motor bearings | 21 Rear wheel bearings |
| 16 Clutch release bearing | Rear axle oil filler |

It is best to use the brakes as little as possible, in order to reduce the wear to a minimum. In making any but an emergency stop, close the throttle—either accelerator or throttle hand lever, disengage the clutch, and let the car coast and thus lose its speed, using either the foot or the hand brake to bring it to a halt only if necessary. This practice is most advantageous in that it reduces wear of the tyres and the brake linings, as well as of certain other parts of the car's mechanism. A quicker stop can be made by disengaging the clutch and, holding it thus, shutting the throttle and pressing forward on the foot brake, varying the degree of pressure to meet the needs of the case.

Emergency Stops—Never bring the car to a standstill as quickly as possible except in an emergency, as this practice is very trying to its various parts. To stop in the minimum time, it is necessary merely to press the clutch and brake pedals as far forward as they will go and at the same time strongly to pull back on the hand brake lever. The maximum braking effort—both brakes being in use—is thus exerted; and as it is possible under these conditions to lock the wheels, due care must be taken to apply sufficient pressure to the brakes only to retard the motion of the wheels and not actually to stop them, otherwise the tyres will be injured by sliding along the road. **A car can be stopped more quickly with the wheels rotating than with them locked.**

Always release the accelerator or shut the hand throttle before disengaging the clutch and applying the brakes. Just before the car comes to a complete halt, release the brakes to prevent the disagreeable jerking that would otherwise follow. Before taking the foot from the clutch, **move the gear lever to the neutral position**; if the stop is to be of any duration, set the hand brake; stop the engine, also, to save fuel and oil.

Descending Hills and Braking with the Engine—It is not necessary nor is it good driving or conducive to long life of the brake linings exclusively to use the brakes in descending even a steep hill. When properly handled, the engine exerts a very powerful braking effort with no wear of the brake linings.

In descending any ordinary grade, therefore, it suffices merely to close the throttle to ensure running at a moderate rate of speed, but in this case the clutch is not disengaged nor are the gears shifted to neutral or to a lower gear. This practice is sufficient for most hills; but if the slope is steep and the driver has any doubt about checking the speed of the car with third speed engaged, he should, **before beginning the descent**, shift to second or even to low; in the latter position he will find he has a very powerful brake.

In running down a hill in this manner, **the ignition should not be turned off**, as such practice will very likely cause a destructive explosion in the muffler when the ignition is turned on again at the bottom of the hill.

Coasting—In driving, one frequently encounters a hill not steep enough to use the engine as a brake and yet too long to coast down with the clutch held disengaged by the foot because of the personal discomfort attendant to

such an operation. Furthermore, it is desirable to avoid holding the clutch disengaged when the car is in motion or the engine in operation for any longer period than is absolutely necessary, in order to minimize wear on the clutch release bearing. In such a case, move the gearshift lever to the neutral position and engage the clutch, the car coasting; if the speed becomes higher than desired, reduce it by a slight application of either the hand or foot brake, alternating in their use, if the descent is very long, to avoid undue heating of either.

Gearshifting in Coasting—When the bottom of the hill has been reached, do not shift into high gear in the ordinary manner, for the gears would then be badly ground. Check the speed of the car to 10 to 12 miles (15-20 km.) an hour and then shift; if grinding then results, or if any difficulty is experienced, do not continue to attempt to make the shift, but reduce the speed of the car still more.

If, when coasting down a hill with the clutch engaged and the gears in neutral, the engine should stop, do not under any circumstances attempt to shift into high or any other gear until the engine has been started or the car brought to a complete stop; violation of this precaution will seriously injure the gears.

Stopping on a Hill—In stopping on a hill, a careful driver will, in addition to setting the hand brake, turn the front wheels to the curb or to the side of the road, to prevent the car from rolling down the hill should the brake be inadvertently released; or he will block the wheels. Some drivers shift the gears into the first speed position after the brake has been applied and the engine stopped, thus further ensuring against the car rolling down the hill, but this practice is not altogether to be recommended; it is far too easy for one to forget, when starting the engine, that the gears are in first speed, and an accident might therefore result. Such practice is, however, a safeguard against movement of a car when it is halted for any period on a hill, but if it is resorted to it should be followed cautiously and carefully.

Starting on a Hill—To start the car on an up-grade, shift into first gear. Gently engage the clutch, as in making an ordinary start, but increase the engine speed by means of the accelerator rather more than when starting on the level, at the same time releasing the hand brake; simultaneously engaging the clutch whilst releasing the hand brake prevents the car from rolling backward, and if the operation is skilfully carried out the car should move forward gradually and smoothly.

Another method is very similar. When disengaging the clutch, preparatory to shifting into first speed, apply the foot brake and then release the hand brake, holding the car from rolling backward by means of the former. Increase the engine speed by means of the throttle hand lever slightly more than when starting on the level. Gently engage the clutch, as in making an ordinary start, and at the same time gradually release the foot brake.

In shifting into second speed, and then, if the hill is not too steep, into

top, increase the speed of the car considerably more than when shifting from first to second on the level. The clutch should be more quickly engaged after shifting than when on the level; the throttle should be opened farther, as more power is needed to drive the car up hill than along a level road.

Hill Climbing—On coming to a steep upgrade, speed up the car as much as road and traffic conditions permit, in order to rush the hill. Press the accelerator down to the floor board if necessary, so as to obtain the maximum power of the engine, but if a pounding—a distinct thumping—is heard in the engine, or a light pinking, it is an indication the spark is advanced too far and should be somewhat retarded; if the pounding persists after retarding the spark, shift into second speed, or even into first. Move the spark hand lever toward the retard position (front or top of sector) until the thumping or pinking ceases, retarding the spark to its limit if necessary. **Do not forget to advance the spark again as soon as road conditions permit.**

It is wise, when approaching a hill which may prove too much for the car to climb on high gear, to shift into second speed at the bottom, or even into first, if any doubt is felt, rather than to be forced to make the shift into a lower gear whilst on the hill.

Mud—Sand—Snow—It is advisable to drive the car in somewhat the same manner when negotiating deep mud or sand, rather than to risk being mired, as might easily happen whilst shifting to a lower gear in the middle of such a stretch. One should not, of course, speed through deep mud or sand, or even snow, as the result might be disastrous, due to uncertain steering under such conditions, but every effort should be made to keep the speed of the car at as high a rate as the bad stretch will permit in order to avoid the ever-present possibility of the speed decreasing—as it undoubtedly will—to such an extent that the car will come to a complete stop, when it might prove impossible to start it again without assistance.

In any stretch of heavy going, the spark and throttle should be handled in the same manner as when climbing a steep hill. The throttle should be kept as wide open as road conditions permit and the spark gradually retarded when any pounding is heard.

Steering—Most beginners are prone to steer too much; they move the wheel too far in steering. This is true of straight running as well as—and more particularly—when rounding a turn. Only a very slight movement is necessary to keep the car on a straightaway. When turning a corner, a greater movement of the steering wheel is required, but the beginner generally turns the wheel too far and experiences considerable difficulty in straightening out, after making the turn, as a result. Round the turn slowly and move the steering wheel just enough to follow it; little difficulty will then be encountered in resuming a straight course.

Skidding—Skidding is one of the bugbears of motoring. Of course, skidding does occur and is frequently fraught with really serious consequences to a car and its occupants, but, on the whole, danger of skidding is

overemphasized out of proportion to its importance because it is easily prevented.

Modern non-skid tyres prevent skidding to a very high degree, but complete—or practically complete—insurance against it can be had through the use of non-skid chains. In bad weather or on slippery roads use chains on both rear wheels; it is a wise practice to use at least one chain on the front wheels, also, particularly when running in snow. Incorrectly adjusted chains damage tyres (see chapter XVII, part three).

A car generally skids on the rear, although it sometimes happens that it skids on the front wheels, also; in addition to skidding on either front or rear wheels, a car may skid on all four. Skidding of the rear of the car is generally caused by too severe an application of the brakes or attempting to make too fast or too sharp a turn when on a slippery road surface; or skidding may result, even on a dry surface, by taking a turn at too high a speed. Brakes—especially unequalized brakes, that is, brakes holding more strongly on one wheel than on the other, are the most prolific cause of skidding.

In attempting to stop quickly on a slippery road the rear of the car will tend to swing to the right or left and to the front. The remedy for this condition is immediately to release the brakes and to turn the steering wheel in the direction the car is skidding, checking the speed by very gently reapplying the brakes. Application of the brakes with the clutch engaged—very gently and carefully made—generally prevents skidding when stopping on a slippery road, but this should be most carefully done lest the transmission mechanism be injured; it should be resorted to only in an emergency.

Skidding on the front of the car or on all four wheels is difficult or even impossible to correct. Only a highly skilled driver is capable of meeting such a situation. Fortunately, however, such skidding is rare and usually results from the driver's rash handling of the car; a careful driver need never fear being forced to face such a possibility.

The First 500 Miles—It is impossible too strongly to emphasize the importance of the first 500 miles (1,000 km.) of any car's life, be that car of the cheapest and crudest or the most expensive and finest. The treatment a car receives and the character of the service it is subjected to during this period are the two basic factors that predetermine the condition of that car when it will have run 10,000 or 20,000 miles or more.

Under a powerful microscope a beautifully polished metal surface will be found to consist of a series of minute irregularities. During the wearing-in process a car is subject to in the first 500 miles (1,000 km.) of use these irregularities are broken or worn down, so that finally an actually smooth surface is obtained. Tiny particles of metal are broken or worn from the moving parts and accumulate in the oil which lubricates them, necessitating frequent changing of the oil. If the speed at which these surfaces move is unduly high for their condition, excessive friction and, consequently, excessive wear must result; the life of the car is proportionately shortened and cost of upkeep likewise increased.

There are but two things to guard against during this period; Excessive speed and careless or insufficient lubrication.

Excessive Speed—The car owner is strongly urged not to drive his car at a higher rate of speed during the first 500 miles (1,000 km.) than the following:

On high speed.....	25 miles an hour (40 km.)
On second speed.....	15 miles an hour (25 km.)
On first speed.....	5 miles an hour (10 km.)

Change the Oil—During the first 500 miles (1,000 km.) of use, drain the oil pan and refill it with fresh oil of the proper grade at the end of each 250 mile (500 km.) period; change the oil in the transmission and rear axle, also, but only after the first 500 miles (1,000 km.) have been covered, and thereafter as recommended in chapter IV, part two.

In carrying out these operations, the owner is referred to chapters I, III, V, and XII, part three, and is earnestly requested implicitly to adhere to these further instructions, as well as to those relative to routine care in part two.

CHAPTER III

NOTES ON LUBRICANTS, FUELS, WATER, SOAPS, POLISHES, ETC.

Which Oil—Correct lubrication is not ensured merely by driving to a garage and asking for a quart (litre) of oil. When an oil or a grease is needed, the car owner or driver should ask for it by name, specifying the desired grade, and then make certain he gets what he asks for. The subject is far too important, and, in the long run, too expensive if carelessly handled, to rely on another's judgment, not because that person may be dishonest but because he may be careless and lacking in a proper conception of what the wrong lubricant may, and very likely will do, to some part of your car.

It has been the policy of many factories in the past in recommending an oil for the engine or other parts of the car to designate that oil as light, medium, or heavy. Recommendations of this nature leave the car owner in total ignorance of just what is meant with respect to the proper lubricant. To meet these conditions, the Research Division of General Motors Corporation has devoted much time and effort and has gone to not a little expense to determine the right lubricant necessary to meet any particular lubrication problem, their findings being given herein for the benefit of the car owner.

Engine Oil—The following specifications are those of an engine oil the car manufacturer recommends for summer use:

ENGINE OIL, MEDIUM

(Spec. No. A-30, General Motors Corp.)

1. GENERAL: The lubricant specified herein must be a properly refined and filtered petroleum oil, free from water, acid, sediment, resins, soaps, or other compounds not derived from petroleum.
2. FLASH POINT: Shall not be below 385° F. (196° C.).
3. FIRE POINT: Shall not be below 425° F. (218° C.).
4. VISCOSITY: At 100° F. (37.8° C.) shall be between 270 and 330 seconds Saybolt Universal.
5. CARBON RESIDUE: Shall not be over 0.5% (Conradson).
7. COLOR: No. 5 N. P. A.
8. POUR TEST: Shall not be above 35° F. (1.67° C.).
9. CORROSION: The oil shall not corrode any metal used for machine construction.

Transmission and Differential Oil—The following specifications are those of a transmission oil suitable for use in the transmission and differential in summer months:

TRANSMISSION OIL

(Spec. No. A-15, General Motors Corp.)

1. GENERAL: The lubricant specified herein must be a properly refined and filtered petroleum oil, free from water, acid, sediment, resins, soaps, or other compounds not derived from petroleum.

2. FLASH POINT: Shall not be below 460° F. (238° C.).
3. VISCOSITY: At 210° F. (99° C.) shall be between 140 and 160 seconds Saybolt Universal.
4. POUR TEST: Shall not be over 60° F. (15.6° C.).
5. PRECIPITATION NUMBER: 1.0 C. C.
6. WATER AND SEDIMENT: 0.5%.
7. CORROSION: The oil shall not corrode any metal used for machine construction.

Winter Oil—The following specifications are those of a transmission oil suitable for use in the transmission and differential in winter months:

TRANSMISSION OIL

(Spec. No. A-9, General Motors Corp.)

1. GENERAL: The lubricant specified herein must be a properly refined and filtered petroleum oil, free from water, acid, sediment, resins, soaps, or other compounds not derived from petroleum.
2. FLASH POINT: Shall not be over 325° F. (162.7° C.).
3. VISCOSITY: At 210° F. (99° C.) shall be between 80 and 100 seconds Saybolt Universal.
4. POUR TEST: Shall not be over 10° F. (-12.2° C.).
5. PRECIPITATION NUMBER: 5.0 C. C.
6. WATER AND SEDIMENT: 0.5%.
7. CORROSION: The oil shall not corrode any metal used for machine construction.

Engine Oil—The following specifications are those of an engine oil the car manufacturer recommends for winter use:

ENGINE OIL, MEDIUM

(Spec. No. A-030, General Motors Corp.)*

1. GENERAL: The lubricant specified herein must be a properly refined and filtered petroleum oil, free from water, acid, sediment, resins, soaps, or other compounds not derived from petroleum.
2. FLASH POINT: Shall not be below 340° F. (171° C.).
3. FIRE POINT: Shall not be below 385° F. (196° C.).
4. VISCOSITY: At 100° F. (37.8° C.) shall be between 270 and 330 seconds Saybolt Universal.
5. CARBON RESIDUE: Shall not be over 0.3% (Conradson.)
6. POUR TEST: Shall not be over 0° F. (-17.8° C.).
7. COLOR: No. 5 N. P. A.
8. CORROSION: The oil shall not corrode any metal used for machine construction.

Note—The references to "summer" and "winter" apply to localities in which temperature variations above and below 30° F. (-1° C.), respectively, are experienced. In warmer climates, where the temperature does not go below 30° F. (-1° C.), the oils recommended for summer may be used during the winter season.

* This specification may be used in summer, also.

MANUAL OF CARE AND OPERATION

A Substitute Winter Oil—During cold weather, difficulty is experienced in the use of ordinary transmission oils, particularly in the transmission, due to the tendency of the oil to solidify. This condition causes difficult gearshifting; channeling occurs, also, that is, the gears in revolving cut channels or grooves in the solidified lubricant, and lubrication of the gear teeth and bearings is therefore impossible. It is suggested that the following mixture be used in winter months in the transmission or differential to obviate this difficulty:

10° to 0° F. (-12° to -18° C.)	Use a mixture of 27% zero cold test engine oil and 73% transmission oil
0° to -10° F. (-18° to -23° C.)	Use a mixture of 50% zero cold test engine oil and 50% transmission oil
-10° to -20° F. (-23° to -28° C.)	Use a mixture of 73% zero cold test engine oil and 27% transmission oil
Lower temperatures than -20° F. (-28° C.)	Use a mixture of 27% kerosene and 73% transmission oil

The following list includes a number of oils that meet the several oil specifications contained herein:*

Gargoyle, Mobiloil Arctic (A-030)	Vacuum Oil Company
Gargoyle, Mobiloil "C" (A-15)	
Monogram, Medium (A-30)	New York Lubricating Co.
Polarine, Medium (A-30, A-030)	Standard Oil Company
Polarine Transmission, Summer	
Polarine Transmission, Winter	
Sunoco, Medium (A-030)	Sun Oil Company
Texaco, Medium (A-030)	Texas Oil Company
Veedol, Medium (A-30)	Tide Water Oil Company

Cup Grease—Soft cup grease, the lubricant generally used on spring bolts, etc., should be a homogeneous mixture of high grade mineral oil and pure lime soap. It should be entirely free from acid and other adulterants and of a soft nature, and have a sufficiently high melting point to prevent free flowing in warm or hot weather.

Crankcase Dilution—Crankcase dilution (see chapter XII, part three), a condition arising from the increasing scarcity of suitable fuels, has of late years become a serious factor in engine lubrication; it results from the difficulty experienced in the carburetion of the low-grade or heavy fuels now in general use and also from overrich mixtures caused by improper use of the carburetor choke, incorrect adjustment of the carburetor itself, or both.

To a certain extent, a preventive may be had in the selection of a good quality fuel, but, unfortunately, the car owner far too often has no choice in this matter, but must take what he can get. However, circumstances may permit his selecting a high quality fuel and a simple test is therefore given below, which, although not altogether accurate, will suffice, nevertheless, to indicate whether a fuel is bad or good; consequently, it will furnish the car owner with a basis for determining which of two or more fuels to choose.

* The numbers indicate the specifications the various oils meet.

Specific Gravity of Fuel—In the selection of a fuel, there are two very important considerations: A fuel must be sufficiently light (volatile) to make for easy starting in cold weather; and it must be as free as possible from heavier fuels, to reduce crankcase dilution to a minimum.

The standard measure of a fuel's lightness or its suitability for use in a motor car engine is its specific gravity, which, although ordinarily an index of its weight, that is, its volatility, can not be entirely relied upon as a true indication of its quality. For example, a fuel of high specific gravity can be produced by mixing a very light fuel with a heavier one, such as gasoline with kerosene. It can be readily seen, therefore, that the specific gravity of such a mixture is of but little value in fixing its desirability.

Testing a Fuel—A very simple method of determining the purity of a fuel and its suitability for use in a motor car engine is the burn test: Pour a tablespoonful of the fuel to be tested into a porcelain or china cup, ignite it, and allow it to burn freely until all the fuel has been consumed, being careful to protect the cup from drafts.

The quantity and character of the residua left on the bottom of the cup are an indication of the purity of the fuel under test. If the bottom of the cup is practically clean, the fuel is good; if a heavy deposit of carbon (a black, sooty substance) is left on the upper walls of the cup and a heavy, black tarry deposit on its bottom, the quality of the fuel is poor; or if an oily residuum be found in the cup, the fuel contains a large quantity of heavier fuels; it is between these two results—a clean fuel and one that leaves heavy residua—that the quality ranging from good to bad lies.

Benzol and Alcohol Mixtures—The use of various mixtures of benzol should be approached with considerable caution, as such mixtures are frequently very corrosive in their action on the cylinders, pistons, valves, etc. This condition is due to impurities not wholly extracted from the benzol during the refining process and which enter the cylinders when a benzol mixture is used as fuel; this is likewise true of alcohol.

A rough test of the freedom from corrosive substances of a benzol or alcohol mixture can be made by immersing a strip of polished steel in it. If the polish of the strip is unimpaired after twenty-four hours of continuous immersion, the mixture may be considered suitable for use; if discoloration or other corrosive action results, the mixture should be avoided if possible.

Water—Dirty water—water that is muddy or more or less filled with solid matter—is undesirable for use in an engine cooling system, due to the danger of such solid matter filling the very small interstices of the radiator, thus preventing cooling; nor is hard water (water containing certain minerals which encrust the surfaces of the water jackets and the radiator tubes) suitable, for it causes poor cooling in that it prevents radiation of heat. Only pure, soft water should be used: rain water; spring water that is potable and free from minerals; water in which soap lathers freely; only these should be used in the cooling system if it is to operate at its maximum efficiency.

Soaps—In selecting a soap for washing the car, use extreme care to secure one as free from strong alkali as possible, as the use of a strong, coarse soap on the highly finished surfaces of the coachwork is very harmful to the varnish and enamel and will soon cause the bright surfaces to lose their lustre. A neutral soap is useless, because in order to remove grease, road oil, etc., a caustic action is necessary, and a really neutral soap is entirely free from this action.

A compromise is therefore necessary. Choose a soap that is relatively free from alkali, one that will not injure the skin and in which it is safe to wash quite delicate fabrics—**and use as little of it as possible.**

Polishes—A metal polish should be entirely free from acids, abrasives, and other destructive agents, as the continued use of such polishes will destroy the nickel plating with which many of the bright metal parts of the car are finished.

Under no circumstances use a polish or renovator on the coachwork—regardless of what the garage man or accessory or supply dealer may say on the subject; most salesmen are more interested in selling a polish to you than in conserving the finish of your car.

Practically all these polishes and renovators contain materials that destroy varnished and enameled surfaces. They impregnate such surfaces with a waxy or greasy coating that temporarily imparts a high lustre but which soon destroys the finish. Many of them are bad because they do not remove the dust and grime, but grind them into the varnish and enamel, thus marring and scratching the finish beyond repair.

Once applied, these preparations are difficult or impossible to remove, and a coach painter therefore is unable to refinish the coachwork except at high expense to the owner.

Bear constantly in mind the fact that low first cost of lubricants, soaps, polishes, and other supplies inevitably means high final cost; the cheapest is the most expensive; only the best is actually the most economical.

PART TWO

ROUTINE CARE OPERATIONS

A LITTLE ATTENTION AND THOUGHT
APPLIED TO THE CARE OF YOUR CAR
WILL ENSURE CONFIRMATION OF THE
BELIEF YOU HAD IN ITS QUALITY
WHEN YOU BOUGHT IT.

CHAPTER I

DAILY OPERATIONS TO BE CARRIED OUT BEFORE TAKING THE CAR FROM THE GARAGE

1. Ascertain the oil level by means of the oil level gauge (1, fig. 5). Add sufficient oil to bring the level to **FULL** on the oil level gauge rod.

Do not attempt to ascertain the oil level nor replenish the oil supply whilst the engine is running. To prevent the entrance of dirt into the engine oil, wipe off the oil filler tube cap before removing it; **securely replace the cap.**

Unless absolutely necessary, **do not operate the engine if the oil level is below the $\frac{1}{2}$ mark on the oil level gauge rod.**

2. Start the engine, and then close the throttle as far as possible without causing the engine to stop; push in the choke rod, but not far enough to cause the engine to stop or to back-fire.

3. Fill the fuel tank and **securely replace its cap.**

4. Fill the radiator with **clean** water and **securely replace its cap.**

5. Examine the tyres—including spares, to see that they are fully inflated; test them with a tyre pressure gauge (see chapter XVII, part three, for correct tyre pressure). Examine the treads of the tyres for cuts; if any are found, do not use the tyre affected until repairs can be made, but replace it with a spare.

6. Before driving the car from the garage, make certain it contains all its equipment, such as tools, tyres, side curtains, etc.

7. As soon as the car is in motion, try both sets of brakes; if they do not readily stop the car, adjust them before driving any distance. See chapter VI, part three, for details.

8. On leaving the garage, or as soon as possible thereafter, **push in the choke rod as far as it will go**, to avoid running on an overrich mixture.

9. As soon as the engine is well heated, note whether sufficient pressure is indicated on the oil pressure gauge. When an engine is cold and the oil therefore thick, the oil pressure may appear to be sufficient even though the oil pump is not functioning properly; in such an event, it will lessen to a dangerously low degree when the engine is hot and the oil thin.

It is wise to form the habit of spending a few minutes as suggested above before taking the car from the garage. Ascertaining that all is in order, that each item of the car's equipment is on hand, and that the tyres, those on the wheels as well as the spares, are fully inflated, will minimize the possibilities of mishaps on the road.

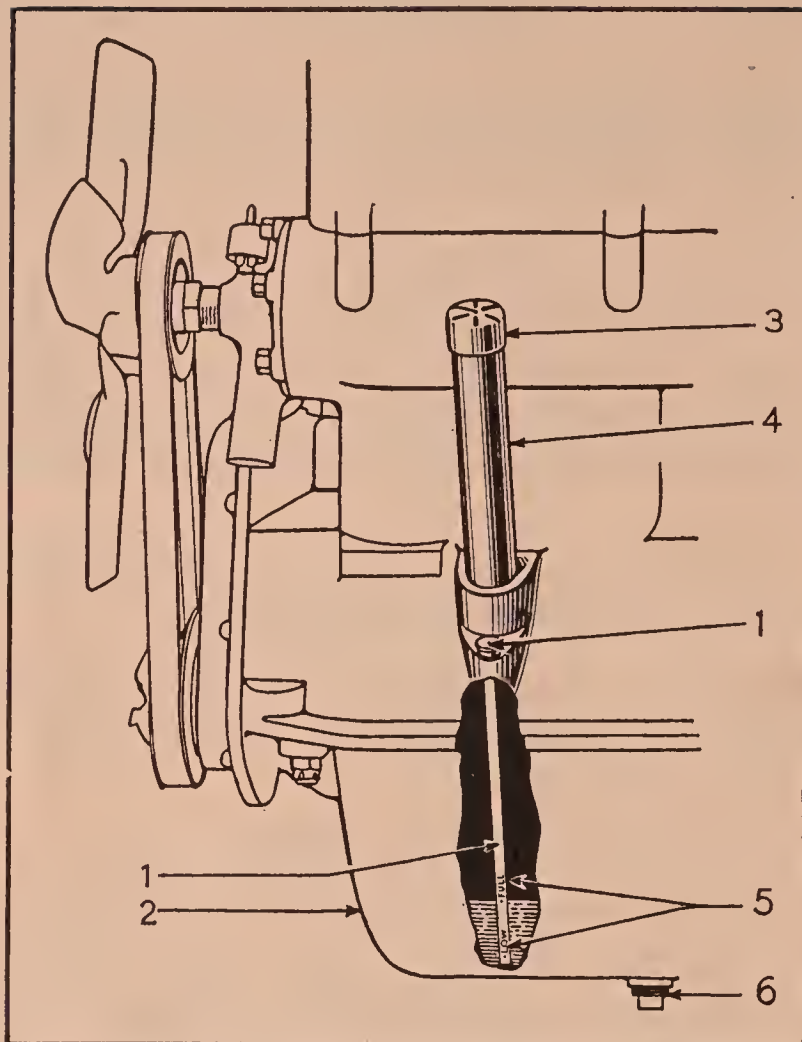


Fig. 5 Oil Level Gauge and Oil Filler Tube

- | | |
|-----------------------|-------------------------|
| 1 Oil level gauge | 4 Oil filler tube |
| 2 Oil pan | 5 Oil level gauge marks |
| 3 Oil filler tube cap | 6 Oil pan drain plug |

Personal Danger—Always bear one very important point in mind: When a motor car engine is run in a closed garage, there is an ever-present danger of the accumulation of noxious gases from the engine exhaust. Carbon monoxide, a constituent of these gases, and very deadly, particularly because the person breathing it has no warning of the danger he is in, is present in large quantities.

For your personal safety's sake, therefore, open the windows and door to ensure ventilation whenever running the engine in a closed place.

CHAPTER II

OPERATIONS TO BE CARRIED OUT EVERY 250 MILES

The following operations* are to be carried out every 250 miles (500 km.), or weekly:

1. Examine the condition of the water in the cooling system; if it is muddy or filled with rust, see chapter XI, part three, for treatment.

The cooling system has a water capacity of 7.5 quarts (6.25 imp. qts., 7.01 l).

2. Whilst the engine is running, apply a teaspoonful of kerosene and engine oil (50% of each) to each valve stem.

3. If the car is dirty, it is best to wash it, in order to conserve the finish; see chapter XIX, part three.

4. Lubricate the clutch release bearing; see 16, 3, fig. 4 and 10, fig. 19.

5. Give the water pump shaft lubricator (9, fig. 37) three or four turns, and refill it with soft cup grease if necessary; examine the gland (8, fig. 37) for leakage.

6. Wipe each of the following parts clean, before as well as after lubricating, and apply a small quantity of soft grease to each with the grease compressor:

A. The steering knuckle pivots (1, fig. 4);

B. The steering knuckle tie-rod pins (6, fig. 4);

C. The rear spring bushings (20, fig. 4).

7. If the car is operated in a very hot climate, examine the storage battery to see that the electrolyte is at the correct level, adding distilled (pure) water, if necessary. Important: See chapter XV, part three, for further particulars.

8. Test the degree of inflation of each tyre with a tyre pressure gauge. If the pressure is 10% or more below normal, inflate to the correct figure.

*In addition to those already mentioned.

CHAPTER III

OPERATIONS TO BE CARRIED OUT EVERY 500 MILES

The following operations* are to be carried out every 500 miles (1,000 km.), or fortnightly:

1. Wash the engine, transmission, and other parts, and as much of the universal joint casing, rear axle housing, etc., as can be conveniently reached, using gasoline or kerosene and a stiff bristle brush and a syringe; wipe dry with a clean cloth. **After washing, oil all parts that require lubrication by hand.**

2. Apply a few drops of engine oil to each of the following:

- A. Spark and throttle controls (at steering gear, carburetor, and distributor);
- B. Oil cups at each end of starting motor;
- C. Brake hand lever bearing;
- D. Gearshift lever bearing (on transmission case cover);
- E. All brake shafts rod ends, and pins;
- F. Brake operating mechanism (on brake bands).

3. See that all electrical connections are tight and clean, not overlooking those on the instruments on the instrument board, ignition distributor, and battery.

4. Remove the ignition distributor cap (locked by two clips) and carefully wipe it out with a clean, dry cloth, free from lint or loose threads, to remove oil or dirt. It may be necessary to wash it with a clean cloth soaked in gasoline; if so, **do not start the engine until the distributor is thoroughly dry**, because of the danger of fire.

5. Take a specific gravity reading of the battery electrolyte, noting whether the latter is at the correct level and adding distilled (pure) water if necessary.

6. Fill the oil cap in the upper rear side of the generator with engine oil.

7. Give the lubricator (10, fig. 4) on the side of the ignition distributor three or four turns, and refill it with soft cup grease if necessary.

Do not for any reason put oil or grease on the generator or starting motor commutators.

8. Fill the oil holes in the valve rockers with engine oil, not forgetting to apply a quantity of oil to the oil felts at the tops of the valve push rods.

9. Screw down the lubricator on the water pump and fan shaft three or four turns; refill with soft cup grease if necessary.

10. Drain and flush the oil pan; see chapter XII, part three, for details. **Fill only with fresh, unused oil**, and do not forget **securely to replace**

*In addition to those already mentioned.

the drain plug. The engine has an oil capacity of 4 quarts (3.3 imp. qts., 3.78 l.).

11. Clean the rear wheel bearing lubricators (21, fig. 4) and apply a small quantity of soft cup grease with the grease compressor.

12. Remove the lubricator (13, fig. 35) from the steering gear case and, with an oil syringe, fill with transmission oil (summer grade); **do not use grease.**

13. Wash and lubricate the springs; see chapter IX, part three, for details.

14. Fill the transmission and rear axle with oil; see chapters III and V, part three, for details.

15. Go over all parts of the car with a wrench and try the various bolts and nuts for looseness. Tighten the engine support bolts, those holding the body to the frame, the mud guard and spring bolts, etc. Pay particular attention to the spring clips and bolts, as broken springs almost invariably result from looseness in these last-mentioned parts.

16. Examine the treads of the tyres for cuts and other injuries and take immediate steps to repair them; see chapter XVII, part three, for details.

17. Examine the front wheel bearings for looseness; see chapter VII, part three, for details.

18. Examine the lining of the foot brake (outer) bands for wear. If they are noticeably thin and the brakes do not hold well after adjustment, reline them; see chapter VI, part three, for details.

At any point where one piece of metal moves on another—door hinges, for example, or mud guards, dust shields, etc.—and which is not otherwise provided with lubrication, apply a few drops of engine oil; fill all oil holes, oil cups, or other lubricators wherever found.

CHAPTER IV

OPERATIONS TO BE CARRIED OUT EVERY 1,000 MILES

The following operations* are to be carried out every 1,000 miles (2,000 km.) or monthly:

1. Drain and flush the oil pan and the lubrication system in general, and then remove the oil pan and clean and replace it; see chapter XII, part three, for details.

2. Drain all the fuel from the fuel tank by removing the drain plug from its bottom; **securely replace the drain plug**. Allow all sediment and water in the fuel to settle to the bottom of the container, and then carefully pour it back into the tank through a chamois skin (see **Caution**, p. 121) or a fine metal gauze strainer. Do not replace all the fuel, thus preventing the sediment and water from entering the tank. **Never strain the fuel through cloth.**

3. Remove the drain plug (11, fig. 41) from the bottom of the vacuum tank and drain the latter; **securely replace the drain plug.**† Remove the strainer (3, fig. 41; 6, fig. 42) from the top of the vacuum tank and carefully wash it to remove all sediment; **securely replace it.**

4. Remove the carburetor drain plugs and the fuel pipe connection (8 and 11 fig. 40). Remove the float chamber cover and take out the float and needle valve (guard against damaging these parts). Wash and flush out all sediment with fuel; do not use a cloth or waste, and be careful not to injure the fuel filter screen. **Securely replace all parts; open the fuel shut-off cock; inspect the fuel pipe connection, drain plugs, etc., for leaks.**

5. Examine the adjustment of the foot and hand brakes, to see that they are equalized; see chapter VI, part three, for details.

6. Apply a **very small quantity** of vaseline or similar lubricant to the surface of the ignition distributor breaker cam (18, fig. 58).

7. Examine the ignition distributor breaker points (14, fig. 58) to see that they open the correct amount; see chapter XVI, part three, for details. **Do not under any circumstances oil the breaker points.**

8. Remove and clean the spark plugs and adjust their points; see chapter XVI, part three, for details. In replacing the spark plug cables, be careful not to get them mixed.

9. Disconnect one of the storage battery cables. Clean the dirt from the commutator covers of the starting motor and generator, remove the covers, and examine the brushes to see that they are making good contact with the commutators, and that they and the latter are clean; see chapter XIV, part three, for details. Replace the covers and **reconnect the battery cable before attempting to start the engine.**

* In addition to those already mentioned.

† Stewart tank only. G. G. tank, remove top and inner chamber and clean sediment from outer chamber.

10. Test the valve clearance; see chapter I, part three, for details.

11. Examine the fan belt. If it is greasy, wash it; see chapter XI, part three, for details.

12. Test the alignment of the front wheels and adjust if necessary; see chapter VII, part three, for details.

13. Drain the cooling system and thoroughly flush it with a solution of lye (caustic soda) or washing soda; see chapter XI, part three, for details.

14. Remove and wash the front wheel bearings. Important: See detailed instructions, chapter VII, part three.

If the car is equipped with wire wheels, remove them and wash the interior of their hubs and the exteriors of the inner hubs (mounted on the axles) to remove all dirt and grease. Wipe dry and apply a light coating of soft cup grease, and replace the wheels, **making certain the hub caps are securely locked.**

15. Disassemble the joint at each end of the steering gear connecting rod—running from the steering gear to the steering knuckle lever, wash with gasoline or kerosene to remove the old grease and dirt, pack with soft cup grease, and reassemble. Any looseness or play in these joints should be compensated at this time by the adjustments provided; see chapter VII, part three, for details. **Do not forget to replace the split pins.**

16. Drain and flush and then refill the transmission and rear axle; see chapters III and V, part three, for details.

17. Test the compression in each cylinder (see p. 58).

CHAPTER V

OPERATIONS* TO BE CARRIED OUT EVERY 3,000† MILES

Disconnect the speedometer flexible shaft and pull the chain out of the casing from the lower end. Thoroughly wash the chain and its casing in gasoline or kerosene, and, when dry, apply a coat of soft cup grease to the chain and replace it in the casing. In reconnecting the flexible shaft to the speedometer and to the speedometer drive gear, be certain the small driving jaws are correctly located.

Under no circumstances apply oil to the speedometer head.

CHAPTER VI

OPERATIONS* TO BE CARRIED OUT EVERY 12,000 MILES

Every 10,000 to 12,000 miles (20,000 to 25,000 km.), or yearly, the car should receive a thorough overhauling. Such parts as the engine, clutch, transmission, universal joint, steering gear, front and rear axles, starting, lighting, and ignition apparatus, etc., should be carefully disassembled and thoroughly cleaned and adjusted before reassembling and installing in the car. All these parts should have the old oil and grease washed out and then repacked with fresh lubricant.

Unless the car owner is familiar with work of this nature, it is advisable that he place his car in the hands of a reliable repair shop and have the above work attended to there. He might do well to take the car to such a shop and consult with them regarding the work, giving his views and receiving those of the repair shop manager. If the services of such a shop are not available to the owner, he is referred to the chapters in part three covering the various parts of the car, in which he will find information that may be of value to him in undertaking this work himself.

* In addition to those already mentioned.

† 5,000 km.

PART THREE

THE COMPONENTS OF THE CAR THEIR CONSTRUCTION, FUNCTION, AND ADJUSTMENT

THE SATISFACTION THAT WILL ACCRUE TO YOU IN THE USE OF YOUR CAR IS PURELY A MATTER OF CHOICE—AND ENTIRELY WITHIN YOUR MAKING. IT WILL BE IN PROPORTION TO THE DEGREE YOU HAVE OR HAVE NOT LEARNED TO THE LEAST DETAIL THE CAR'S OPERATION AND CARE.

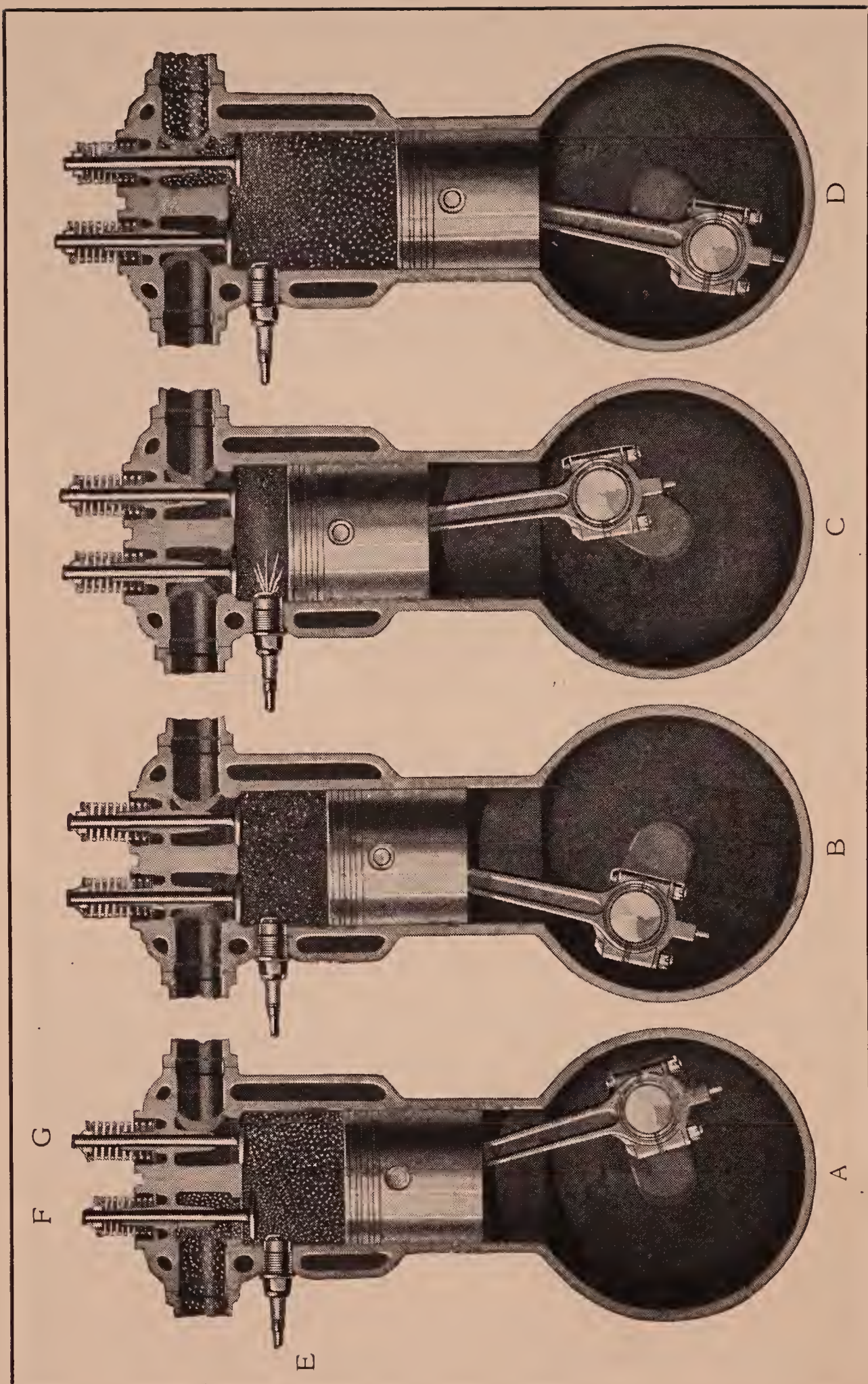


Fig. 6. Four-Stroke Cycle Diagram

- | | | | |
|---|--------------------|---|----------------|
| A | Inlet stroke | D | Exhaust stroke |
| B | Compression stroke | E | Spark plug |
| C | Firing stroke | F | Inlet valve |
| G | Exhaust valve | | |

CHAPTER I

THE ENGINE

There are in use today three types of motive power for automobiles—the gasoline engine (known as the internal combustion engine), the steam engine, and the electric motor. Of these, the gasoline engine is in almost universal use.

Internal Combustion—Internal combustion means that combustion takes place within something—a stove, a furnace, or an engine. For example, in a gasoline engine, fuel—gasoline, kerosene, alcohol, etc.—is mixed with air and admitted into the cylinders, where it is ignited and burned, power being derived from the expansion of the gases produced by the combustion of this mixture.

Cycle of Operation—When such an engine is in operation, the pistons move down, then up, first with one valve and then another opening and then closing, drawing in charges of fuel and air, and igniting, burning, and exhausting them as long as the engine is working.

Whilst the engine is running, we see a series of cycles, each comprising a complete set of operations—hence the general name two and four cycle engine.

The piston starts from the top of the cylinder and moves to the bottom and then returns to the top. Each one of these operations is known as a stroke; and, as it takes four complete strokes to complete one cycle of operations, we call this type of engine a four-stroke cycle—commonly, a four cycle—engine.

The Four-Stroke Cycle—According to the dictionary, a cycle is a complete course of operations of some kind, returning into itself and restoring the original condition. This is a general definition of the term; let us now see just what its meaning is when applied to the principle under which a four cycle gasoline engine operates; in other words, how the engine works.

In detail, the four strokes of the cycle are as follows:

Inlet Stroke—(A) The piston starts from the top of the cylinder and moves to the bottom. Just as it does so, the inlet valve (see fig. 6) is opened and the piston draws a charge of fuel (gasoline, for example) mixed with air from the carburetor through the inlet manifold and inlet valve into the cylinder. The inlet valve remains open until the piston has reached the bottom of the stroke (the bottom of the cylinder—the limit of the piston's travel), when it closes. This is the first, or inlet or suction stroke.

Compression Stroke—(B) The piston then moves to the top of the cylinder, which is now filled with a charge of fuel and air; and, as both valves are closed, the piston in moving upward compresses this charge into the constantly decreasing space in the head of the cylinder, thus preparing the charge for ignition and combustion. This is the second—the compression stroke.

Firing Stroke—(C) When the piston has reached the end of the stroke and is at the top of the cylinder, and with both valves still closed, the com-

pressed charge is ignited by the spark which occurs at this moment at the spark plug. The charge of now burning fuel and air expands with explosive rapidity and power and drives the piston downward with great force. When the piston arrives within a short distance of the bottom of the stroke, the exhaust valve is opened and the still burning and expanding gases rush out through this valve and the exhaust pipe and muffler to the outer air. This is the third, or firing or power stroke.

Exhaust Stroke—(D) The piston, with the exhaust valve still open, now moves to the top once more, forcing out of the cylinder what burned gases there still may remain therein, and, at the end of the stroke, the exhaust valve closes. This is the fourth and last, or exhaust stroke.

Timing an Engine—It will be noted the crankshaft makes two revolutions to each cycle, whilst four strokes of the piston are required for the same result. Note also that each valve is opened but once in each cycle—the inlet valve on the inlet and the exhaust valve on the exhaust stroke; also, that each of these valves opens and closes only at certain points in the cycle.

To provide for these contingencies, the crankshaft timing gear is just one-half as large as the camshaft timing gear, thus driving the camshaft at one-half the speed of the crankshaft. In assembling the engine, therefore, the camshaft timing gear is meshed with the crankshaft timing gear in such a fashion that the valves open and close only at certain exactly fixed points in the inlet, compression, firing, and exhaust strokes.

In precisely the same manner is this true of the ignition. The spark should occur only at the top of the compression stroke, but once in every two revolutions. (As a matter of fact, if the spark is advanced to the normal driving position, ignition takes place somewhat before the top of the compression stroke.)

Setting or adjusting the timing gears and the ignition is known as timing the engine and should never be attempted by a novice. Such work should always be placed in the hands of the most highly skilled and experienced mechanics available, for if it is not properly done the engine will run very badly or it may not even run at all.

Valve-in-Head Construction—There are a number of very important reasons for the valve-in-head form of construction. The gasoline engine is a heat machine, deriving its power from the heat developed in burning a mixture of fuel and air within its cylinders. The type of engine, therefore, that conserves in the highest degree the heat units in each charge of fuel and air will show the greatest efficiency and economy in service, other things being equal.

Of all internal combustion engines this condition is most closely met in the valve-in-head type. It will be noted by reference to A, figure 7, that the valve-in-head engine has but a very small proportion of its combustion chamber walls exposed to the heat of combustion; on the other hand, the valve pockets in the sides of the combustion chambers in any other type of engine present a

much larger proportion of combustion chamber surface to the combustion of fuel and thereby waste a larger percentage of this heat.

It follows, therefore, that the valve-in-head type more closely approaches the ideal than any other. Its thermal efficiency is highest—which means it extracts the largest possible amount of energy from the fuel; from the owner's point of view, it delivers more miles to the gallon.

In order to have perfect combustion, two conditions are essential: One, the cylinders must be completely cleared of all burned gases before a fresh charge of fuel and air is admitted; and two, the spark plugs must be located as closely as possible to the center of the mass of gas so that rapid ignition can be obtained, otherwise slow and therefore wasteful combustion will take place.

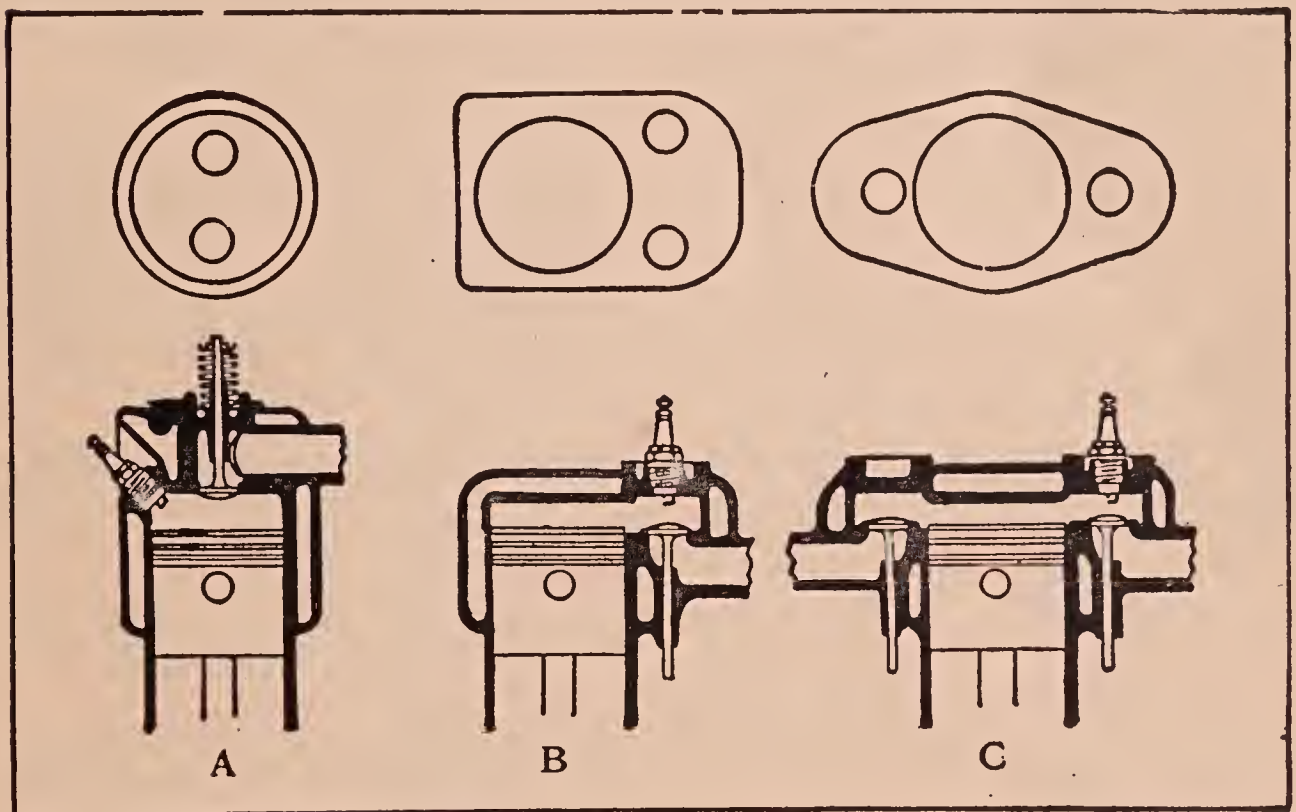


Fig. 7. I-, L-, and T-Head Engine Valve Arrangement

Each of these conditions is completely met in the valve-in-head engine. Because the valves are in the cylinder head and directly over the pistons, the gas, in entering and leaving, flows in a straight line—the shortest possible path and the one of least resistance. The other requisite, that of spark plug location, is likewise fully met in this type of engine, as will be seen by reference to figure 7. The spark plug position in practically every other type of engine is usually over the valves and consequently at some distance from the center of the cylinder. This location is inefficient and ignition (combustion) accordingly takes place much more slowly than in the valve-in-head type. Such a condition militates against obtaining the maximum efficiency and results not only in less power but also in largely increased operating costs.

There is still another advantage in valve-in-head construction—that of accessibility of the valves and the valve-actuating mechanism; in other words, minimum repair charges. The simplicity of this arrangement is so great that many owners can personally handle such more or less difficult operations as valve-grinding, carbon removal, and the like, thus saving repair costs that owners of other types of engines must submit to with whatever grace they can muster.

One other desirable detail should not be overlooked: The cylinders and the cylinder head are not in one piece; the latter is attached to the former by a number of cap screws, with a heavy copper-asbestos gasket interposed to prevent leakage of water and gas. This feature is of very great value to the car owner in that it facilitates making certain repairs and adjustments that would otherwise prove both difficult and costly. It has been in use on these engines practically since their inception, and it is worthy of note that other manufacturers are coming more and more to the same form of construction.

Improper Functioning of the Engine—Most of the items listed below result from carelessness or abuse in caring for the engine; a large number of them rarely or never occur; none can be ascribed to defects of construction. As a general proposition, it can be truthfully said that, barring accident, practically every case of improper functioning of an engine results from neglect or oversevere service; prompt and thorough attention to routine care will prevent them all.

Detailed instructions, where needed, will be found in the pages following the list.

ENGINE FAILS TO START

REASON	SYMPTOM	CAUSE	REMEDY
Air leaks	Hissing or whistling sound at carburetor, inlet manifold, or valve stems	Loose or broken carburetor or inlet manifold gasket; worn valve stem guides	Tighten, or replace if necessary
Cylinders flooded with fuel	Fuel dripping from carburetor or muffler	Carburetor choke pulled out too far	Crank engine with spark plugs removed until cylinders are dry
		Carburetor float jammed	Release by raising and lowering needle valve; see p. 121
		Leaky carburetor float Dirt on needle valve seat	Repair or replace float Rotate needle valve on its seat; drain carburetor; see p. 123
Improperly adjusted carburetor or choke	Engine runs irregularly; may back-fire; starts, then stops	Carelessness	Adjust choke properly; see p. 11-12
Water or dirt in fuel	Back-firing in carburetor; engine starts, then stops	Careless handling of fuel; failure to keep fuel system clean	Drain and wash out fuel system; carefully strain fuel when filling
Carburetor frozen	Back-firing in carburetor, or engine will not start	Accumulation of water in float chamber	Drain, and apply hot cloths. Do not use a flame
No fuel	Engine will not start; starts, then stops	Carelessness; leaks	Fill fuel tank; repair
Engine too cold	Engine starts and then stops; back-firing; no power; sluggish action		Drain cooling system and fill with hot water, or apply hot cloths to carburetor and inlet manifold. Do not use a flame
Ignition switch not on	No spark	Carelessness	Turn on switch
Weak battery	Starter does not crank engine		Have battery charged; see page 136
Dirty or broken spark plugs	No or poor spark at plug points	Too rich a mixture or improper lubrication; rough handling of plugs	Clean, or replace if necessary; adjust carburetion; use proper oil

ENGINE FAILS TO START (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Ignition distributor out of order	No or very weak spark	Improper adjustment; dirty or wrongly adjusted breaker points; wires short - circuited or broken; broken brushes; dirty distributor	Adjust and clean
Improper spark plug gaps	Misfiring	Lack of attention; points burned	Adjust
Defective battery terminals	Misfiring	Loose or corroded	Tighten and clean
Wiring system out of order	Starter motor will not run; no or poor spark	Lack of attention	Tighten connections or repair or replace broken wires
Improper connections of spark plug cables	Misfiring; engine may tend to run backwards	Carelessness	Connect properly
Incorrect valve or ignition timing	Weak explosions; back-firing; engine may tend to run backwards	Improper assembly	Time engine
Broken or weak valve springs	Back-firing		Replace
Broken or bent valve	Back-firing; poor compression	No lubrication; carelessness	Repair or replace
Poor compression	Weak explosions	Leaky valves; bent valve; broken valve or spring; improper valve timing; broken or worn pistons or rings; incorrect valve clearance; leaky cylinder head	Adjust, or replace and refit parts affected if necessary; see p. 58

ENGINE MISSES AT LOW SPEED

Improper spark plug gaps	Missing on hard pull	Burned electrodes and improper adjustment	Adjust, or replace if necessary
Partly discharged battery	Weak spark	See chapt. XV, part three	See chapt. XV, part three

ENGINE MISSES AT LOW SPEED (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Air leaks	Back-firing in carburetor		See ENGINE FAILS TO START
Dirt or water in fuel	Back-firing in carburetor	Careless handling of fuel	See ENGINE FAILS TO START
Improper carburetion	Back-firing; irregular running		Adjust carburetor
Poor compression	Poor power		See ENGINE FAILS TO START
Worn valve stem guides	Possibly back-firing in carburetor; poor power	Lack of lubrication; carelessness	Repair, or replace if necessary

ENGINE MISSES AT HIGH SPEED

Improper spark plug gaps	Misfiring on hard pull	Burned points or improper adjustment	Adjust, or replace if necessary
Dirty ignition distributor breaker points	Misfiring	Lack of attention; carelessness	Clean and adjust
Weak ignition distributor breaker spring	Misfiring		Replace
Improper carburetor adjustment	Back-firing; irregular running		Adjust
Dirt or water in fuel	Backfiring in carburetor; irregular running	Careless handling of fuel	See ENGINE FAILS TO START
Ignition out of order	Weak spark; dirty spark plugs; loose connections	Lack of attention	Adjust; clean; tighten
Cracked distributor head	Difficult to detect		Have examined by expert
Bent valve stems	Valves affected tend to remain open	No lubrication of valve stems; lack of attention	Straighten if possible and grind; if not, replace, grinding new valve
Air leaks	Back-firing in carburetor; irregular running	Lack of attention	See ENGINE FAILS TO START

ENGINE MISSES AT HIGH SPEED (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Improper fuel feed	Back-firing in carburetor; irregular running	Dirt in fuel; careless filling of fuel tank	Clean out fuel system

ENGINE MISSES AT ALL SPEEDS

Improper carburetion	Backfiring; irregular running; sluggish action	Improper adjustment; dirt or water in fuel; high altitude	Carburetor choke rod in or out too far
Improper fuel	Difficult starting; back-firing; fuel knocks; poor power; sluggish action		Adjust carburetor; some fuels require different carburetor from that fitted
Bent or jammed float needle valve	Back-firing; fuel dripping from carburetor or muffler	Rough handling; dirt in fuel	Release; straighten valve, or replace if necessary; drain carburetor
Dirt or water in fuel	Back-firing in carburetor	Careless handling of fuel	See ENGINE FAILS TO START
Improper lubrication	Usually accompanied by overheating or excessive smoking	Improper oil; worn or broken pistons or rings	Flush lubrication system and fill with proper oil; replace broken or worn parts
Incorrect ignition	Misfiring; poor power; spark knocks	Lack of attention	Adjust, clean, tighten connections, etc.
Air leaks	Back-firing in carburetor; poor power	Lack of attention	See ENGINE FAILS TO START
Poor compression	Weak explosions	Lack of attention	See ENGINE FAILS TO START
Broken or weak valve spring	Back-firing; irregular action		Replace
Broken or bent valve	Back-firing; irregular action	Improper lubrication, lack of attention	Straighten or replace, grinding new valve
Improper valve clearance	Valve does not completely seat; valve clicks loudly	Lack of attention; improper adjustment	If clearance too small, adjust and grind valve; if too large, adjust

ENGINE OVERHEATS

REASON	SYMPTOM	CAUSE	REMEDY
No water	Steam at radiator; cold radiator tubes	Carelessness, or leak in cooling system	Fill cooling system; repair leak if necessary
Water pump	Cold radiator; hot cylinders	Parts broken; see fan, below	Replace broken parts
Fan	Not rotating, or running slowly at all engine speeds	Fan belt greasy, loose, or worn; lack of lubrication	Wash or replace belt; lubricate pump shaft; water pump gland may be too tight
Bent or broken fan blades		Rough handling; abuse	Repair or replace
Frozen radiator	Cold radiator, with steam escaping	Carelessness	Thaw; use hot water or have car removed to warm place; Do not start engine
Improper lubrication	Poor power; knocking; engine hard to crank	Too little or no oil; dirty oil; worn oil pump	Flush lubricating system and fill with proper oil; replace worn parts if necessary; test oil pressure gauge
Too rich a mixture	Heavy black smoke at exhaust and strong odor; irregular running; back-firing in muffler; no speed	Improper adjustment of carburetor; bent needle valve; leaky float; dirty needle valve seat; vacuum tank out of adjustment; high altitude; choke rod pulled out	Adjust, clean, or repair
Running with retarded spark	Loud exhaust; back-firing in muffler	Carelessness	Advance spark
Ignition timed too late	Loud exhaust; back-firing in muffler	Improper timing	Time properly
Carbon accumulations in cylinders	Poor power; knocking, particularly on hard pull	Lack of attention; improper lubrication or carburetion; running with choke rod pulled out	Clean out cylinders; use proper oil; adjust carburetor; run less at choke position

ENGINE OVERHEATS (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Brakes dragging	Hot brake bands and drums; poor speed and power; excessive fuel consumption	Carelessness; lack of attention or lubrication	Adjust brakes; lubricate brake mechanism
Choked muffler	Poor power; hissing sound at muffler	Mixture constantly rich; improper lubrication; improper fuel; carelessness	Very rare; disassemble and clean muffler; adjust carburetion; use proper oil

ENGINE STOPS

Ignition switch off	Engine stops suddenly	Accidental	Turn switch on
No fuel	Engine stops slowly; back-fires in carburetor	Carelessness; dirt in fuel nozzles and strainers; shut-off cock closed	Fill fuel tank; clean carburetor; open fuel shut-off cock
Water or dirt in fuel	Engine stops slowly; back-fires in carburetor	Careless handling of fuel	See ENGINE FAILS TO START
Carburetor flooded	Fuel dripping from carburetor; engine stops slowly, runs unevenly; explosions in muffler; strong odor to exhaust	Carburetor choke pulled out too far; leaky float; bent or jammed needle valve; dirt on needle valve seat	Examine and adjust carburetor float and needle valve; flush out carburetor; push choke in
Throttle closed too far	Engine stops suddenly (when car is not in motion)	Improper adjustment of throttle	Adjust throttle stop-screw
Defective wiring	Engine stops suddenly or may run intermittently before stopping	Broken or short-circuited wires; lack of attention	Repair, or replace if necessary

ENGINE KNOCKS

Carbon in cylinders	Poor power; knocking on heavy pull; overheating	Improper carburetion or lubrication; lack of attention	Clean out carbon; use proper oil; adjust carburetion
Spark advanced too far	Usually on a hill or in heavy going	Careless driving	Retard spark, and shift to next lower gear if necessary

ENGINE KNOCKS (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Running too long on high gear	Usually on a hill or in heavy going	Careless driving	Shift to next lower gear
Faulty lubrication	Engine overheats; no or little pressure on oil pressure gauge; engine hard to crank	Defective oil pump, oil piping, or oil pressure gauge; no or too little oil; dirty oil	Replace broken or worn parts; clean out lubricating system and refill with fresh oil of the proper grade
Overheated engine	Poor power; water boils; engine suddenly stops; engine knocks	Defective water or oil circulation; no water or oil; water leaks; retarded spark; dragging brakes; slipping clutch; carelessness	Allow engine to cool; fill with water or oil and see that the circulation is good; examine brakes and clutch; advance spark
Loose connecting rod bearing	A pronounced thumping in engine	Defective lubrication; wear; improper assembly	Adjust; it may be necessary to replace bearings
Loose piston pin bearing	Light metallic click	Same as connecting rod bearing	Replace with oversize piston pin
Loose main bearing	Very heavy thump in engine	Same as connecting rod bearing	Same as connecting rod bearing
Loose piston	Light metallic click in cylinder; piston slap	Same as connecting rod bearing	Replace with oversize piston
Broken piston rings	Light metallic click in cylinder	Mostly by defective lubrication or careless assembly	Fit new rings; possibly cylinder may be scored
Loose fly-wheel	Intermittent, heavy thumping	Broken split pins on nuts; loose bolts; careless assembly	Tighten nuts and replace split pins
Improper valve clearance	Pronounced metallic clicking at valves	Wear or improper adjustment; lack of attention	Adjust clearance
Use of unsuitable fuel	A knock similar to advanced spark		Use another kind of fuel, or install carburetor suited to the fuel being used

ENGINE KNOCKS (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Fuel knock	Similar to advanced spark	Improper carburetion	Readjust carburetor: usually a slightly richer mixture compensates this condition

ENGINE WILL NOT STOP

Overheated engine	Engine continues to run intermittently and is very hot	Usually careless driving; lack of attention; abuse	Pull choke out as far as it will come; shut off fuel feed; stall engine by starting on high gear
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Carbon deposit	Engine runs intermittently after switch is turned off	Excessive accumulation of carbon in cylinders; lack of attention	Proceed as in overheated engine; remove carbon deposit by cleaning
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LACK OF POWER

Poor compression	Sluggish action	Lack of attention	See ENGINE FAILS TO START
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Too weak or too rich a mixture	Back-firing in carburetor; explosions in muffler and strong odor	Improper adjustment of carburetor	Adjust carburetor
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Operating engine in high altitude	Sluggish action; black smoke or strong odor to exhaust	Too little oxygen in the air	Adjust carburetor to lean mixture
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Poor ignition	Weak spark	Defective ignition apparatus	Adjust, or have apparatus examined by expert
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Ignition timed too late	Overheating; back-firing	Improper adjustment	Time properly
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Running with retarded spark	Overheating; back-firing	Careless driving	Advance spark
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Improper valve timing	Back-firing; loud exhaust	Improper assembly	Time properly
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Improper adjustment of valves	Poor compression; loud metallic clicking at valves	Carelessness; lack of attention	See pages 55-57
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Lack of lubrication	Overheating; knocking	Lack of attention	Examine lubrication system
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LACK OF POWER (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Lack of cooling water	Overheating; knocking	Lack of attention	Examine cooling system
Dragging brakes	Hot brake bands and drums; excessive fuel consumption	Improper adjustment; lack of attention	Adjust brakes
Lack of fuel	Sluggish engine action and back-firing in carburetor		Fill fuel tank
Slipping clutch	Engine speeds up with no effect on car speed	Oil or grease on clutch lining; worn clutch lining; broken or weak clutch spring; lack of attention	Wash; adjust; replace parts if necessary
Tyres		Punctured or nearly deflated	Replace or inflate
Choked muffler	Overheating; hissing at muffler	Mixture constantly rich; improper lubrication; improper fuel; carelessness	Rare; remove muffler and clean; adjust carburetor; use proper oil; use different fuel

BACK-FIRING THROUGH CARBURETOR

Dirt or water in fuel; air leaks	Poor power; sluggish action	Careless handling of fuel	See ENGINE FAILS TO START
Inlet valve open	Poor compression	Not closing properly, due to too close clearance, bent valve stem, lack of lubrication	Adjust clearance and grind valve

BACK-FIRING IN MUFFLER

Ignition timed too late	Loud exhaust; poor or no power; overheating	Improper adjustment	Time properly
Improper mixture	Sluggish action; strong odor and black smoke to exhaust	Mixture too rich	Adjust carburetion
Improper ignition	Misfiring; poor power	Lack of attention	Adjust ignition system

BACK-FIRING IN MUFFLER (Continued)

REASON	SYMPTOM	CAUSE	REMEDY
Exhaust valves not closing properly	Valves stick open; poor or no compression	Too small a clearance; weak or broken valve springs; bent stem; lack of lubrication	Adjust and grind valves; replace broken or worn parts
Improper valve timing	Poor power	Improper assembly or adjustment	Time and adjust properly
Whilst coasting down hill and braking with engine		Accumulations of unburned gas in the muffler	Keep throttle closed whilst coasting
Overrich mixture	Overheating; black smoke and strong odor to exhaust; irregular, sluggish action; poor power	Defective carburetion; vacuum tank out of order	Adjust

Timing Marks—Reference to figure 8 will disclose that certain of the timing gears bear punch marks. These gears are correctly set in relation to one another and the positions of the pistons—and the valves therefore correctly timed—when the punch marks coincide (are in line) with one another. A series of marks, made use of in timing the valves as well as the ignition, is inscribed on the fly-wheel, also these marks are visible through removal of the toe boards.

Valve Timing When New Gears are Installed—When replacing the crankshaft or camshaft timing gear with a new one, it will be necessary to retime the valves, and the ignition, also; see chapter XVI, part three, for details of this latter operation.

Remove the cylinder head (see **Grinding the Valves**). Crank the engine by hand until No. 1 piston (the one nearest the radiator) has reached its uppermost position, when any further movement will cause it to descend; this position is known as upper dead center.*

Continue very carefully to crank the engine until No. 1 piston has moved downward exactly $\frac{1}{16}$ " (1.58 mm.); it is at this point that the inlet valve should open.

Remove the starting crank, as the piston must not be again moved until the timing operation has been completed; replace the cylinder head and the valve push rods.

* The upper dead center can also be found by means of a screwdriver inserted through the spark plug hole in No. 1 cylinder, so as to touch the top of the piston, but this method is not as accurate as the method outlined above. See fig. 9.

Install the new timing gear, engaging it with the old one (already in place) in such a manner that the inlet valve of No. 1 cylinder **begins** to open when the new gear is fully in place. Great care must be exercised exactly to ascertain this point, because, due to the obliquely cut teeth of the timing gears, the camshaft is slightly rotated when the new gear is pushed into place.

The point at which the inlet valve begins to open can be accurately determined by inserting a piece of heavy letter paper between the valve rocker and the valve stem. Move the paper back and forth in this position whilst meshing the gears, and as soon as any tightness is felt, that is, when the paper can no longer be freely moved, the valve is **beginning** to open. It may be necessary to set the gears in several positions before this point can be located.

Mark the Gears—When the valves are correctly timed and the timing gears installed, permanently mark the latter—a punch mark on a tooth of one gear and another punch mark between two teeth of the other gear, the punch marks to be in line with one another when the gears are in place, but only at that point at which the inlet valve in No. 1 cylinder should **begin** to open.

Valve Clearance—Too large or too small valve clearance causes faulty operation of the engine. When the clearance is too large, a loud clicking noise is heard in the valves, which are not completely opened; more or less

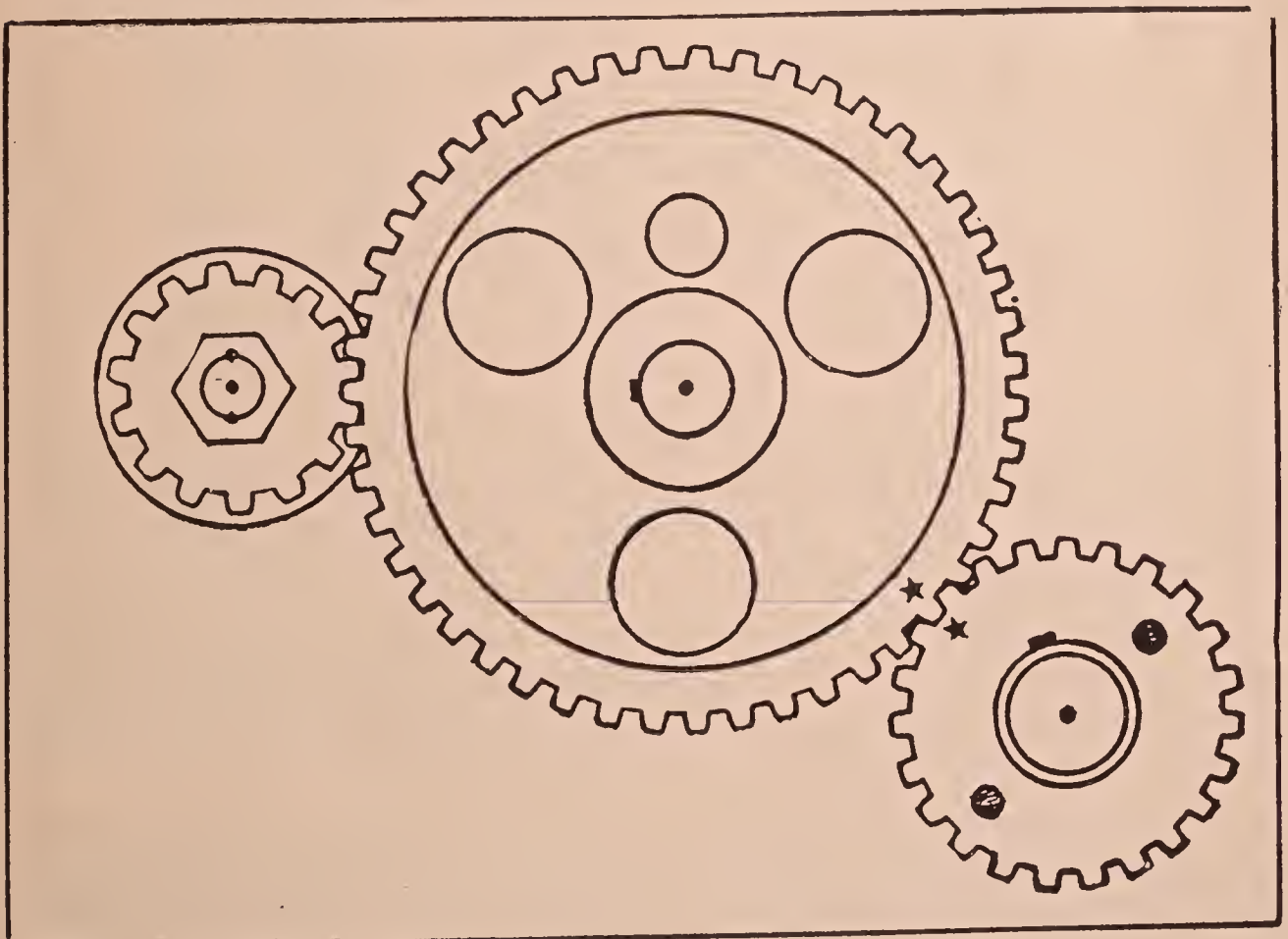


Fig. 8. Timing Gears

Left—Generator driving gear
Center—Camshaft timing gear
Right—Crankshaft timing gear

decrease in power results. Too small a valve clearance causes lessened power, also, because in this case the valves do not close completely and compression is therefore poor.

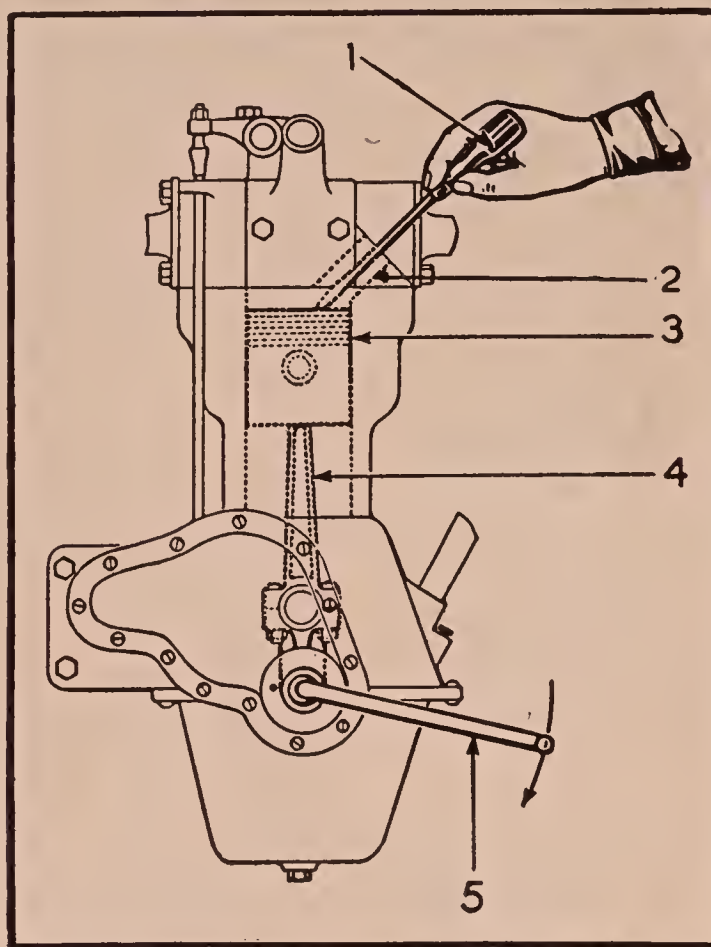


Fig. 9. Locating Upper Dead Center

- | | | | |
|---|-----------------|---|----------------|
| 1 | Screwdriver, | 3 | Piston |
| 2 | Spark plug hole | 4 | Connecting rod |
| 5 | Starting crank | | |

When the valves do not close because of too small clearance, they and their seats in the cylinder head are damaged by constant exposure to the hot gases. Whenever this condition is encountered, the valve affected should be ground and the clearance adjusted.

To adjust, proceed as follows: Crank the engine by hand until the valve whose clearance is to be adjusted has opened and closed, **continuing the cranking $\frac{1}{8}$ th to $\frac{1}{4}$ th of a revolution of the hand crank beyond the closing point of the valve.**

Loosen the lock-nut (B, fig 10) at the right hand end of the valve rocker. Insert a thickness gauge (a piece of sheet metal of appropriate thickness; see fig. 12) between the valve rocker and the valve stem. Turn the adjusting-screw up or down until the thickness gauge is quite tightly held between the valve rocker and the valve stem. At this point, securely hold the adjusting-screw from turning farther and tighten the lock-nut; the adjustment is correctly made when, on removing the gauge, a slight resistance is felt.

The valve clearance is the space between the valve rocker and the valve stem, measured when the valve is fully closed. This space should measure 0.006" (0.15 mm.) for both inlet and exhaust valves, **when the engine is hot or at least very warm.**

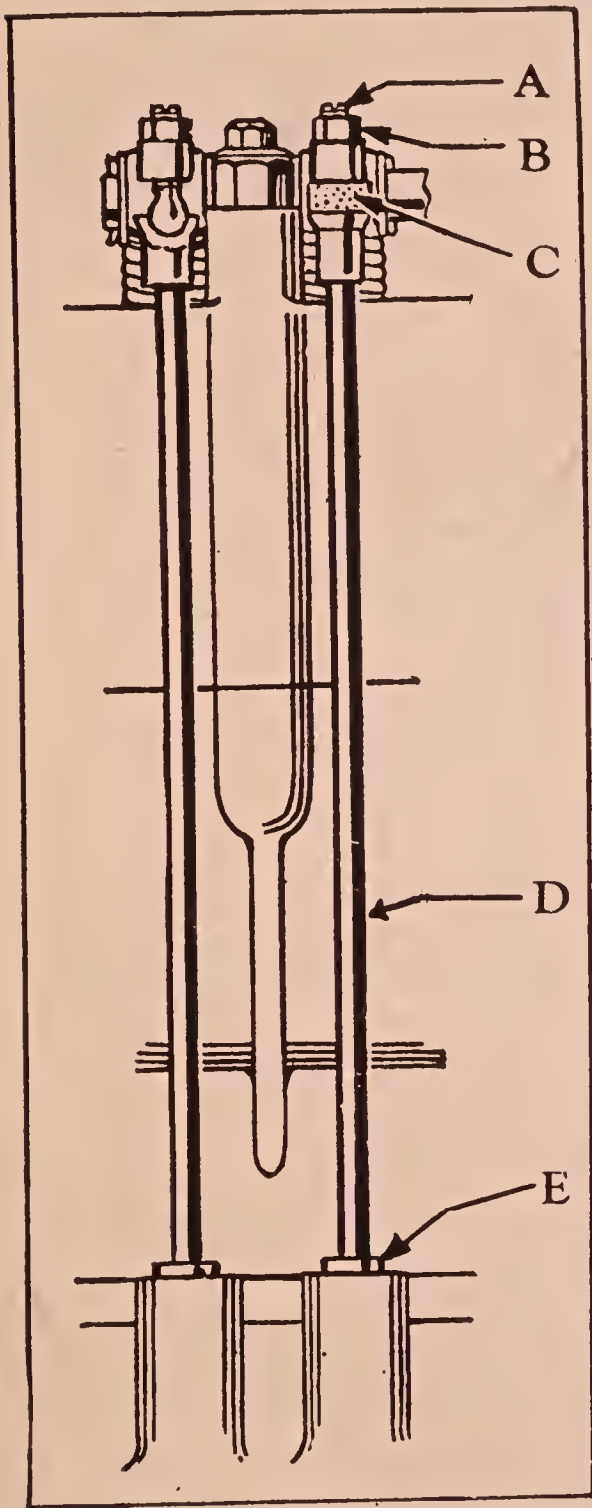


Fig. 10. Valve Push Rods

- A. Valve clearance adjusting-screw
- B. Valve clearance adjusting-screw lock-nut
- C. Valve rocker oil felt
- D. Valve push rod
- E. Valve lifter

If a thickness gauge is not available for use, a sheet of heavy letter paper or very light card, either of which is about 0.006" (0.15 mm.) in thickness, can be used.

Caution—In turning the fly-wheel to any of the timing marks on it, as in timing the valves or the ignition, be careful to turn it only in a clockwise direction—to the right, the direction in which the engine runs, viewed when

facing the front of the engine—otherwise back-lash in the timing gears (looseness or play between their teeth) will prevent accurate results.

Routine Care—The valve stems, the valve rockers, the oil felts, the valve lifters, and the valve lifter guides require periodical lubrication; they should also be frequently washed with gasoline or kerosene. Be guided in this respect by the instructions in part two, ROUTINE CARE.

Apply a teaspoonful of kerosene and engine oil (50% of each) weekly (every 250 miles; 500 km.) to each valve stem and valve stem guide whilst the engine is running. This treatment reduces carbon accumulations on the valves, prevents their sticking in their guides, and lubricates them.

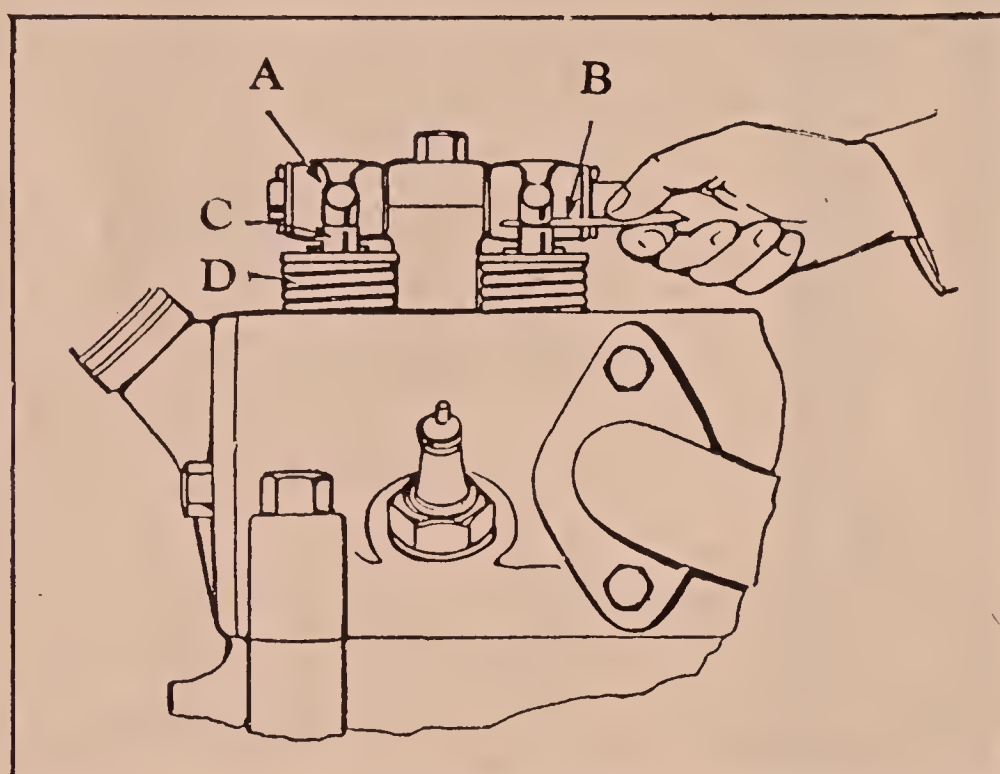


Fig. 11. Measuring Valve Clearance

A. Valve rocker B. Thickness gauge C. Valve stem D. Valve spring

Failure properly to lubricate the valves, valve stem guides, and other parts of the valve mechanism results in bent or even broken parts, in addition to rapid wear. Faulty engine operation follows; power decreases; fuel and oil costs are augmented.

Testing the Compression—Due to leaks at various points, such as valves in poor condition, worn pistons and piston rings, loose or broken spark plugs, defective cylinder head gasket, etc., the compression in the cylinders lessens; in other words, the full power of the expansion of the burning gases is not exerted against the pistons to drive the car. The efficiency and economy of the engine are therefore adversely affected.

Test the compression whilst the engine is hot, or at least very warm; each cylinder is, of course, individually tested. Insert the hand crank and slowly

pull up on it, noting whether the degree of resistance encountered is the same in each cylinder. If a marked difference is noted in one or more cylinders, take immediate steps to correct the condition, such as grinding the valves, cleaning or replacing piston rings, fitting new (oversize) pistons,* tightening cylinder head bolts, fitting new cylinder head gasket, etc.

Compression leaks are not difficult to detect. Loose or broken spark plugs cause a rather loud hissing sound when the engine is running or being cranked, as do a poor cylinder head gasket and loose cylinder head bolts; these latter are also responsible for the accumulation of water in the cylinders and leakage

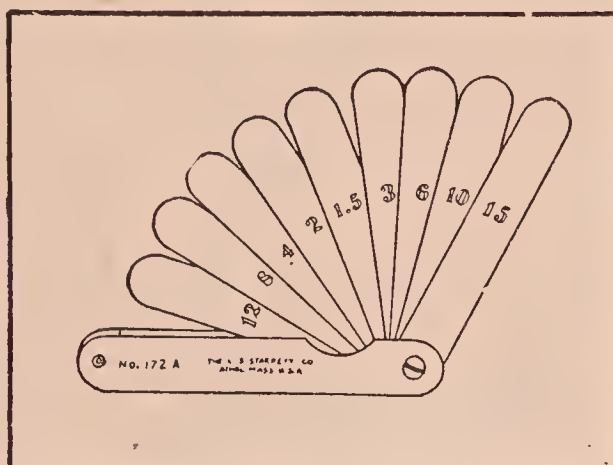


Fig. 12. Standard Thickness Gauge

of water at the joint between the cylinders and the cylinder head. Worn or broken piston rings or pistons cause rapid crankcase dilution and give off a peculiar, purring sound, quite audible when the engine is throttled down; it is best heard through removal of the oil filler tube cap.

If the compression is poor, tighten the spark plugs and the cylinder head bolts (whilst the engine is hot or very warm), and should the condition persist, grind the valves. Then, if these measures fail, have a capable shop examine the pistons and rings and make the necessary repairs.

Grinding the Valves—Drain the cooling system by opening the drain cock (3, fig. 37) and disconnect the engine water outlet (the elbow-shaped pipe at the front end of the cylinder head), taking care not to damage its gasket. Disconnect the inlet manifold and exhaust pipe, being careful not to injure their gaskets. Remove the spark plugs to protect them from breakage and then the cylinder head bolts. Lift off the cylinder head, guarding against injury to the cylinder head gasket.

To remove a valve, place the cylinder head on a flat, wooden surface and press down on the valve spring retainer (the cup-like washer at the top of the valve spring), to permit removal of the valve spring retainer lock (a small cotter-pin holding the valve spring retainer in place). Mark the valve nearest the front end of the cylinder head No. 1 and the next No. 2, and so on to No. 8—the rearmost valve, to prevent their being mixed.

* Only when accompanied by piston-slap.

Turn the other side of the cylinder head up, remove the valves, and carefully wash and scrape them, their guides (their bearings in the cylinder head), and the cylinder head free of carbon, oil, etc. Clean the cylinders and pistons in the same manner. Avoid scratching these parts, as this would promote the rapid formation of fresh accumulations of carbon. If the valve stems are rough or gummed, polish them with fine emery cloth or paper.



Fig. 13. Removing a Valve Spring

Apply a thin coating of a good valve grinding compound (fine emery powder mixed with engine oil to the consistency of a rather thin paste will suffice) to the beveled edge of the valve. Insert the valve into the opening from which it was removed and turn it back and forth on the valve seat (in the cylinder head) until the beveled edge and the seat are well polished. During this process it will be necessary frequently to wipe off the beveled edge and the seat with a cloth wet with gasoline or kerosene to note the finish.

Do not rotate the valve continuously in one direction, but give it a quarter-turn one way and a half- to a third-turn the other, and frequently lift it clear of the seat. If the valve is not rotated on its seat farther in one direction than in the other, and rotated still farther when lifted clear of its seat, the valve and its seat will be badly scored; deep rings, very difficult to remove, will be cut in the valve and its seat. Rings or scores and pits must be completely removed before a tight valve can be had; the grinding must be continued until the valve and its seat show a uniform, dull, grey surface.

Caution: Remove Every Vestige of the Grinding Compound—On completing the grinding, thoroughly wash the valves, their seats and guides,

and the adjacent parts of the cylinder head with gasoline. **Take the utmost care that no vestige of grinding material remain on any part of the valves or cylinder head**, for the entrance of such matter into the cylinders will prove most destructive.

Test the quality of the finished grinding by marking the beveled edge of the valve or its seat with lead pencil or chalk. Turn the valve against its seat a few times; if the marks are **entirely** rubbed off, the work has been well done; if not, grinding must be continued.

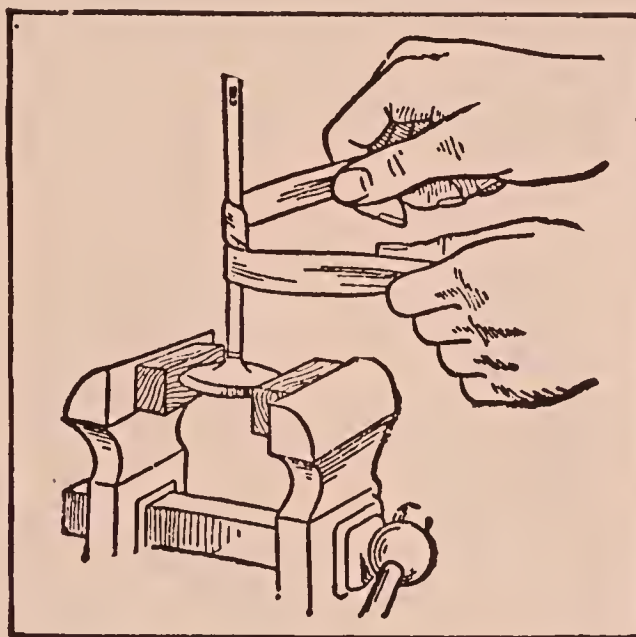


Fig. 14. Polishing a Valve Stem

The use of a valve grinding tool for this work greatly facilitates its prompt and easy completion, or a carpenter's brace or bitstock will be satisfactory. Much better and more easily accomplished results can be obtained in this manner than by means of a screwdriver—the usual tool.

In the event that the valves are in very bad condition and a good, tight seat can not be obtained by grinding, it will be necessary to turn them down (smooth off the beveled edge) in a lathe or other suitable tool and then grind them.

Always adjust the valve clearance after grinding the valves, as this latter operation removes a certain amount of metal from the valves and seats and thus increases the valve clearance.

Before placing the valves in the cylinder head, oil the valve stems and the valve stem guides.

Replacing the Cylinder Head—Examine the cylinder head gasket; if those parts adjacent to the cylinder openings and the water holes are free from marks or depressions and the surface is smooth and unbroken, it can be used again; otherwise, replace it. Never shellac the cylinders, the cylinder head, or the cylinder head gasket. Before placing the gasket in position, apply a coating

of soft cup grease to both sides to hold it in position on the cylinders whilst the head is being installed and to prevent its possible corrosion or adhesion to the cylinders or cylinder head on future removal. See **Hose Connections**, p. 103.

Caution—When the cylinder head is in place, insert the cap screws and turn each one down until its head just touches the cylinder head. Then, with a wrench, tighten each one a little at a time, until all are equally tight. Tighten the cap screws in the order shown in figure 16; when the engine has been run and is hot, tighten them again, in the manner stated above. Replace the remainder of the parts, taking particular care not to damage any of the gaskets, and fill the radiator.

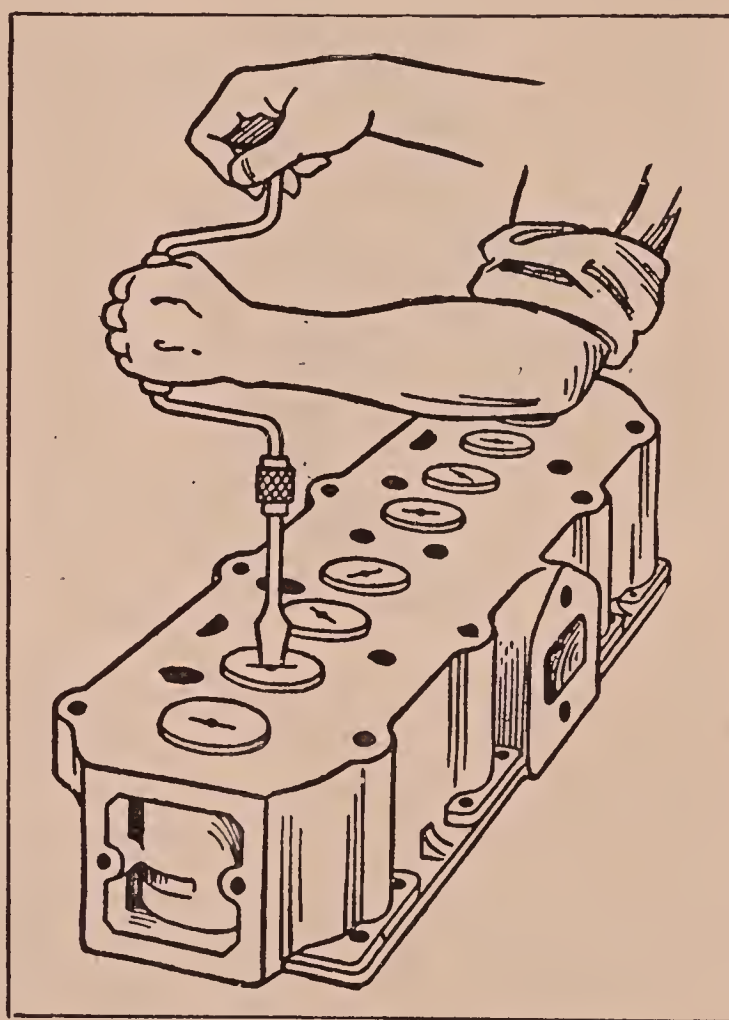


Fig. 15. Grinding Valves

Valve Springs—A broken or weak valve spring will cause the engine to run badly. To locate such a spring, insert a screw driver or similar tool between the coils of the spring whilst the engine is running and twist or turn the tool, thus increasing the spring tension. If this has a marked effect on the running of the engine and causes it to improve, replace the spring under test.

The tension of a valve spring can be temporarily increased by removing it and stretching it about 1 inch (25 mm.); or the same effect can be secured by placing a number of washers between the spring and the spring retainer. In a short time, however, the spring will have to be replaced.

Bent Valve Stems—A bent valve stem sometimes results from accident; generally, however, it is due to carelessness or to lack of lubrication or cleanliness. A valve in this condition sticks open, causing the engine to run badly. Remove such a valve and straighten and polish its stem; if a satisfactory repair does not result, replace it, taking care to grind the new one fitted and also to adjust its clearance.

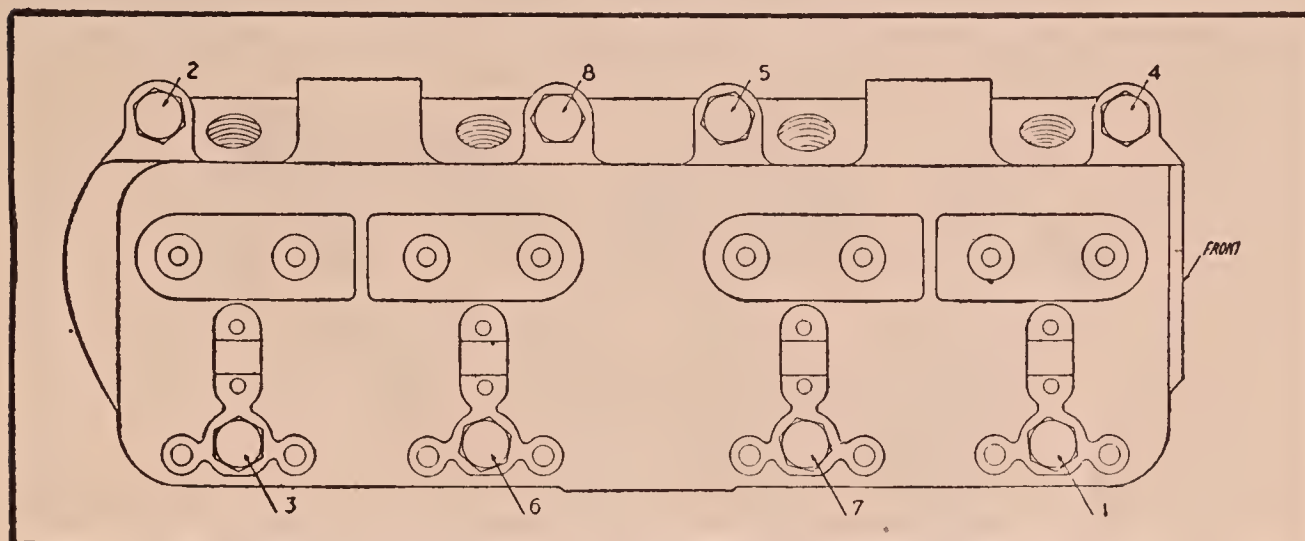


Fig. 16. Cylinder Head Bolt Tightening Diagram

Scored Cylinders—Defective lubrication or improper use or care of the engine may cause scored cylinders; scored pistons or broken piston rings may also result. It is necessary to regrind scored cylinders and to fit them with oversize pistons; if only the pistons or piston rings are damaged, replace them with carefully fitted new ones of the proper size.

Removing Pistons—The pistons can be removed either through the crankcase or through removal of the cylinder head, but inasmuch as it is also necessary to disconnect the connecting rod bearing to remove a piston, it is best to drain and then drop the oil pan and take out the piston and connecting rod through the opening thus provided.

The pistons are attached to the connecting rods by the piston pins, which are fixed in the pistons by special cap-screws and lock-washers. To remove a piston from a connecting rod, unscrew the cap-screw with a heavy screw-driver and gently tap the piston pin out of the piston, using a light hammer and a block of hard wood.

Piston Rings—Exercise great care in removing piston rings from pistons, as they are easily broken. Insert a knife blade or similar tool (see fig. 18) between the ring to be removed and the piston, slipping the knife blade around the piston, at the same time lifting the ring out and up with the hand, working it off the piston in this manner.

This operation is reversed (see fig. 18) in installing piston rings, but equal care must be exercised; three knife blades are used instead of one. Slip the piston ring over the top of the piston, but do not let it drop into the first piston ring groove. Insert the three knife blades between the piston ring and the

piston at equidistant points, and slide the ring down on them until the groove in which the ring is to be placed has been reached, when the knife blades may be withdrawn.

Caution—New pistons must be fitted to cylinders and new piston rings to pistons, as good results can not be otherwise had. In every case it is best to have an expert mechanic do this work, as it calls for not a little skill and judgment.

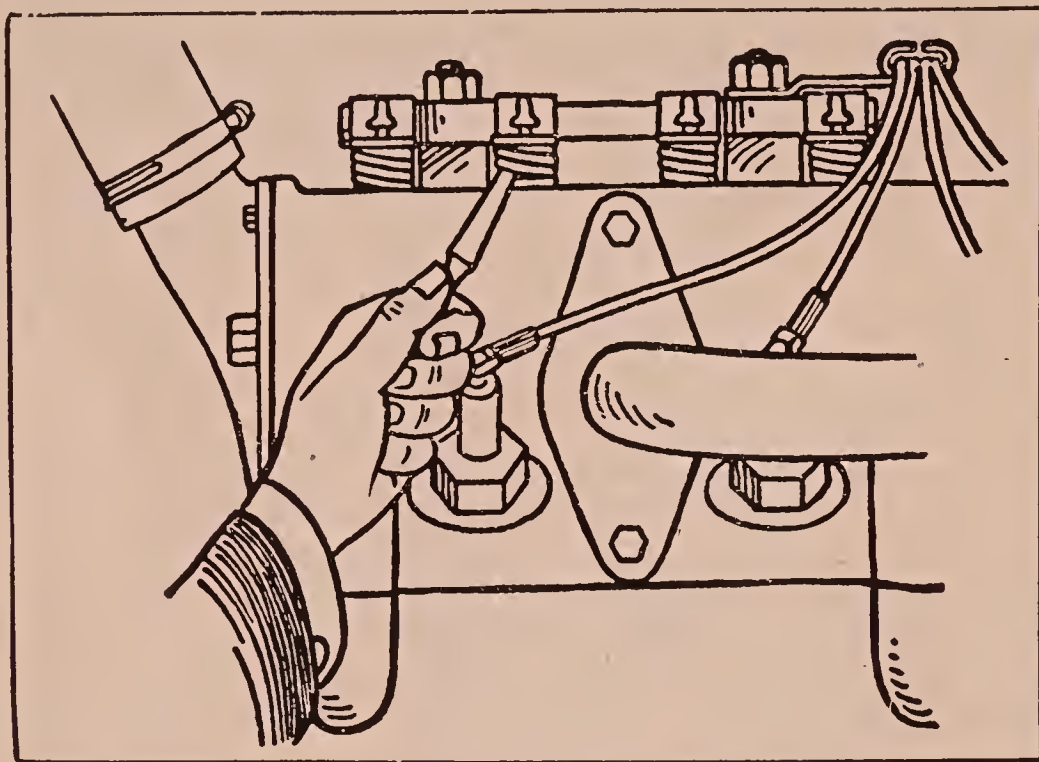


Fig. 17. Testing the Tension of a Valve Spring

Carbon—Accumulations of carbon in the cylinders are manifested by pronounced knocking in the engine whilst climbing a hill or undergoing a heavy pull, especially when the engine is hot. In many respects, a carbon knock is similar to that of too far advanced spark in that it is a rather light sound, quite different from the noise produced by a loose connecting rod or main bearing. If such a knock is heard whilst climbing a hill and retarding the spark has no effect on it, carbon is undoubtedly the cause.

Removal of Carbon—Carbon can be readily removed by means of an oxygen torch introduced into the cylinders through the spark plug holes. Better results are had, however, by taking off the cylinder head and scraping and washing it and the cylinders clean; be careful not to scratch the surfaces, as this will promote the rapid formation of fresh accumulations of carbon.

When carbon accumulations have been neglected, it may be necessary to remove the pistons and piston rings to clean out the carbon that will then have lodged in the piston ring grooves, preventing the piston rings from functioning properly and thus causing poor compression.

Adjusting Engine Bearings—To adjust an engine bearing, proceed as follows:

Drain and remove the oil pan. Examine all the bearings to locate the loose one, which can be easily detected by pushing against it and pulling it and noting whether it moves. (In examining an engine bearing for looseness, do not confuse end play with vertical play. A bearing—connecting rod, for example—may have end play, that is, it may slide lengthwise on a crankpin and yet have no vertical play or looseness. Vertical play is wear, in which case the bearing is larger in diameter than the shaft it is fitted to.)

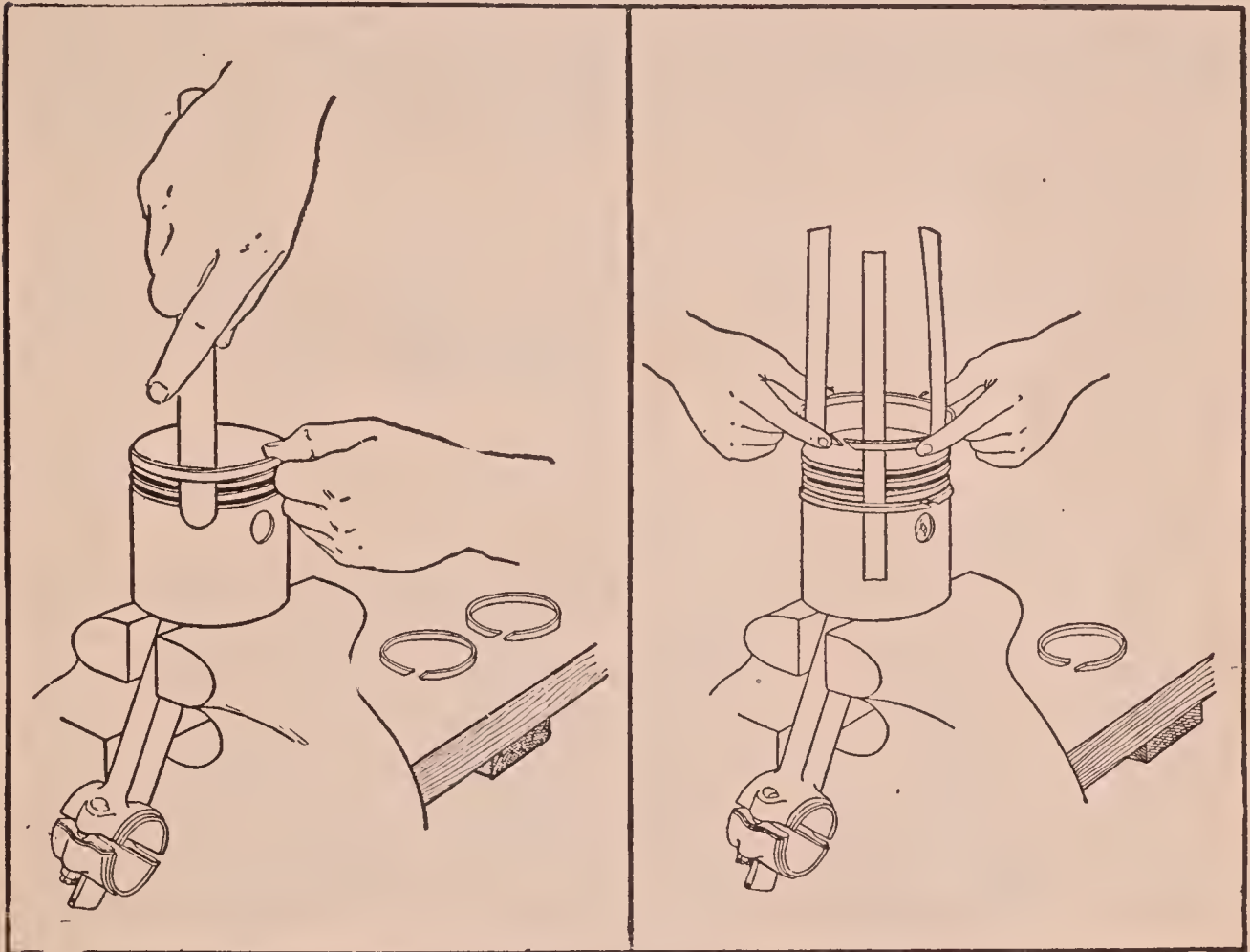


Fig. 18. Left—Removing Piston Rings Right—Installing Piston Rings

Remove the bearing bolts and then the bearing cap; the latter contains the lower half of the bearing. In doing this work, be very careful to keep the two sets of shims (thin metal liners or spacers) separate, and do not forget to examine the upper half of the bearing to see that none of the shims is adhering to it. Before removing the bearing, mark the upper and lower halves so that in replacing them they will be installed in the same positions they were in before removal.

Always remove the same number of shims from each side of the bearing. Replace the remaining shims and the bearing cap, being careful not to bend the former, insert the bolts, and draw the nuts up tight. If the bearing is still loose, remove additional shims (the same number from each side) and replace the cap as before. Continue in this manner until the bearing is tight, when the nuts should be tightly drawn up and the split pins (use new ones) inserted and bent to prevent the nuts from working loose.

If several bearings are loose, tighten and then loosen each one separately before proceeding with the next loose one, and then tighten all and replace and bend the split pins.

Do not tighten the bearings too much or the crankpins will be damaged or the bearings themselves burned out; it should be possible quite easily to turn the crankshaft after the bearings have been correctly adjusted.

Installing Main Bearings—In order to remove or to install the upper halves of the front and rear main bearings, the crankshaft must be removed from the engine. When fitting a new upper half to the rear main bearing, cut a small notch in one of the corners of the inside (front) end of the bearing so as to provide an oilway.

Removal of the crankshaft is a difficult operation and should be undertaken only by a skilled mechanic. It is best accomplished by lifting the engine from the frame, this being done after the bolts holding the clutch hub to the clutch gear shaft, and the clutch operating mechanism and the radiator have been removed.

After the bearings have been fitted, every care must be exercised correctly to align the engine with the transmission.

Caution: Use Plenty of Oil; Do not Run the Engine Fast—Replace the oil pan and pour into it 5 quarts (4.1 imp. qts., 4.73 litres) instead of the usual four (3.3 imp. qts., 3.78 litres). Start the engine and let it run at a low rate of speed for three or four hours before using the car; do not exceed a speed of 25 miles (40 km.) an hour for the first 100 miles (150 km.) thereafter,

Caution: Oil Pan—In carrying out the above or other operations involving the removal of the oil pan, always take advantage of such opportunities to wash it, the oil screen, and the connecting rod oil troughs before replacing it.

Loose Fly-Wheel Bolts—An extremely rare and very puzzling knock is caused by the loosening of the bolts holding the fly-wheel to the crankshaft, a condition accompanied by a heavy thumping, intermittent in intensity and interval. If this knock is traced to the fly-wheel bolts—all other causes having already been eliminated, test the fly-wheel bolts for looseness by endeavoring to rock the fly-wheel back and forth. If a movement other than that which would naturally result from such a procedure—turning of the crankshaft—is noted, the fly-wheel bolts are loose. The remedy is removal of the transmission and tightening of the bolts.

It is not at all a difficult or arduous task properly to care for an engine's needs—if this care be in the form of periodical cleaning, tightening, and lubrication of the various parts at regular and frequent intervals. If, however, the engine receives care only occasionally, when the car owner has nothing better to do, it may fail him when he most needs it.

CHAPTER II

THE CLUTCH

Why a Clutch is Necessary—In setting a motor car in motion, it is necessary first to start the engine and then, with the engine running, to start the car. This condition is met by introducing between the engine and the transmission a coupling device which, at the will of the operator, establishes a rigid connection of the engine with the transmission or breaks this connection, as may be required in operating the car.

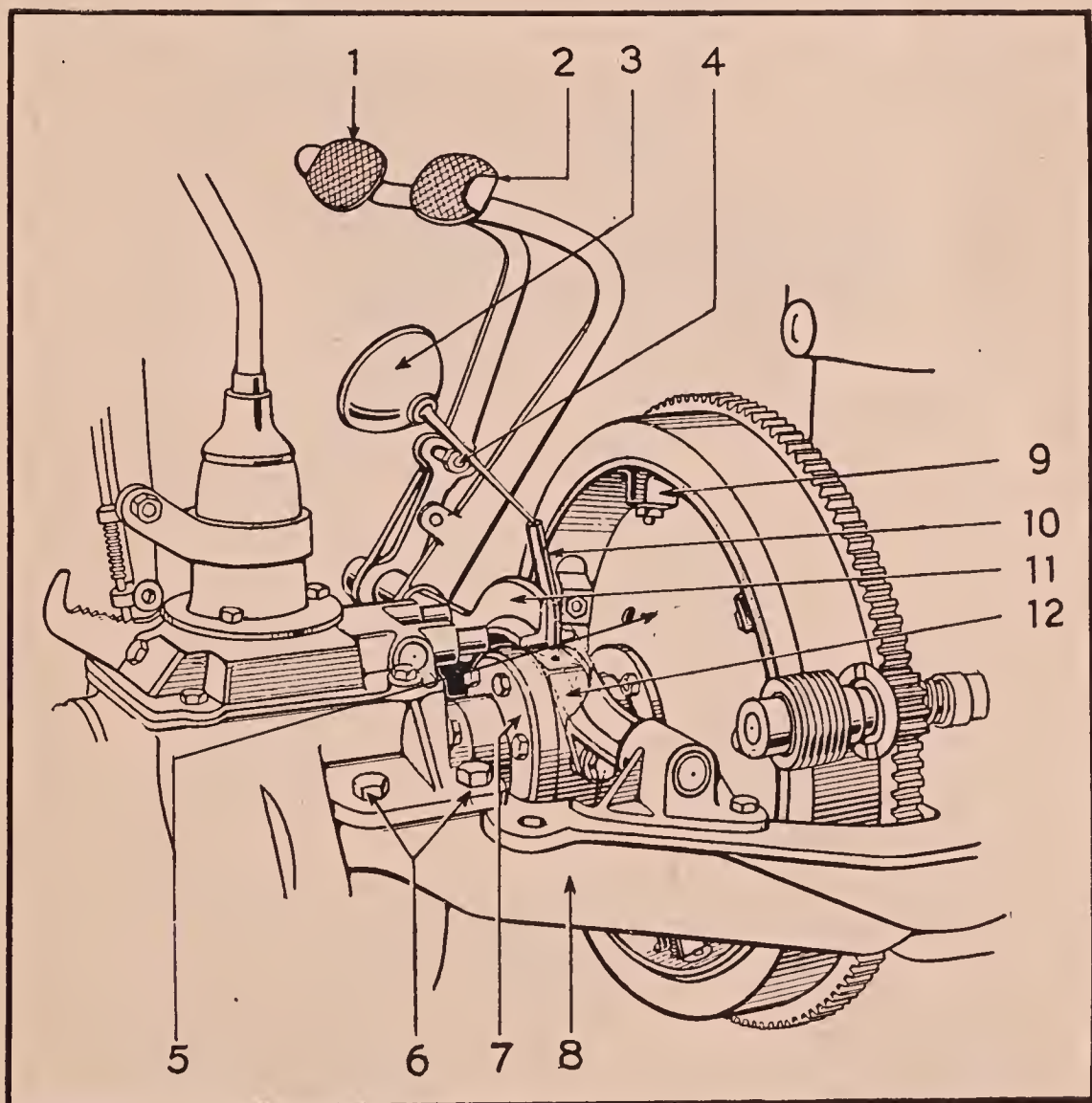


Fig. 19. Clutch Control Mechanism

- | | |
|--------------------------------|------------------------------------|
| 1 Clutch pedal | 8 Transmission support arm |
| 2 Brake pedal | 9 Clutch leather expander |
| 3 Oil can | 10 Clutch release bearing oil pipe |
| 4 Clutch pedal adjusting-screw | 11 Clutch release yoke |
| 5 Clutch cone | 12 Clutch release bearing |
| 6 Transmission bolts | |
| 7 Clutch hub | |

The Friction Clutch—The device with which this is accomplished is known as a friction clutch, deriving this name from its property of setting up

so much friction when in operation that it holds without slippage to that part of the engine to which it is attached; its more common designation is clutch.

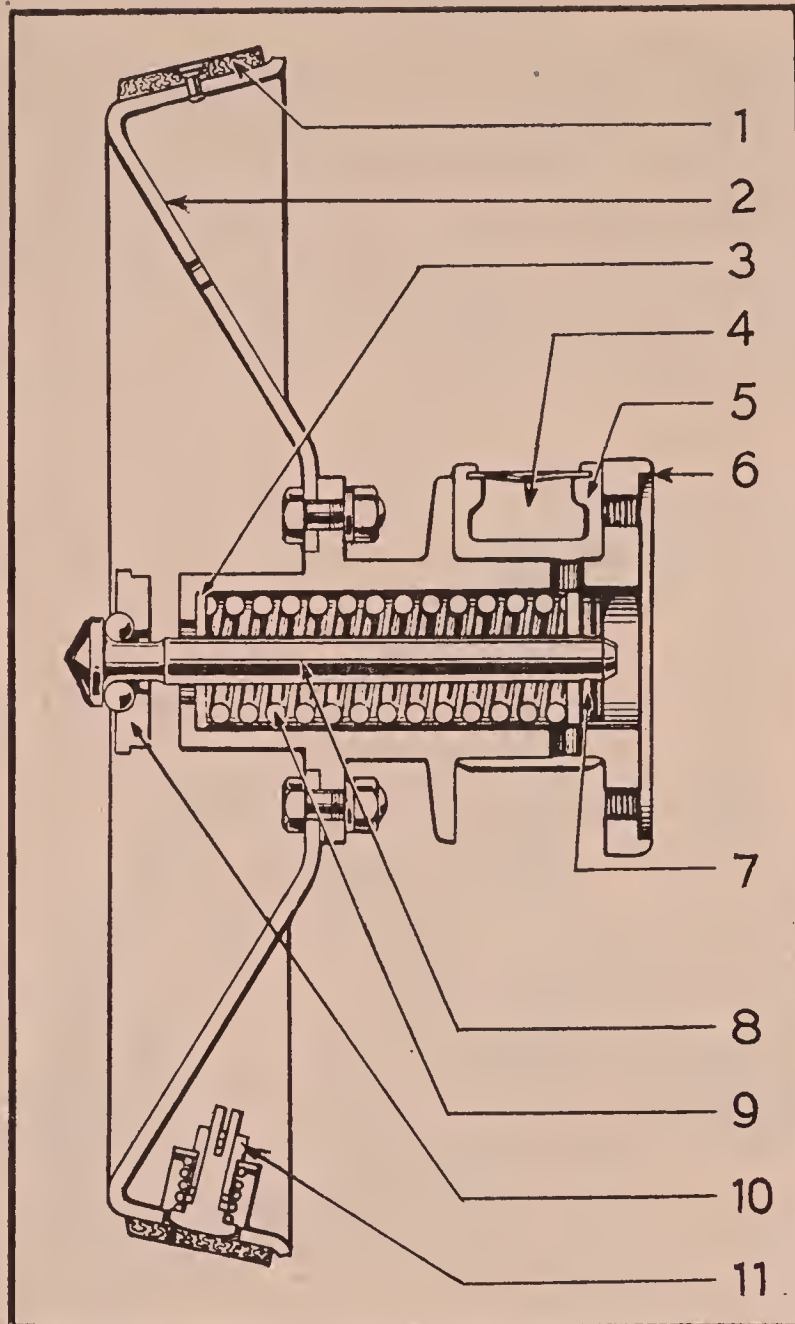


Fig. 20. Clutch Mechanism

- | | |
|--|---------------------------------|
| 1 Clutch lining | 7 Clutch spring retainer pin |
| 2 Clutch cone | 8 Clutch spring tension rod |
| 3 Clutch spring retaining-washer | 9 Clutch spring |
| 4 Clutch release bearing oil reservoir | 10 Clutch spring thrust bearing |
| 5 Clutch release bearing | 11 Clutch leather expander |
| 6 Clutch hub | |

For small, light, low-powered cars the leather-faced cone is ideal. It is simple to a degree, has a very long life, and requires a minimum of attention to keep it in perfect working order. Replacement of the frictional surface of the clutch cone—its leather lining—is readily and inexpensively effected, but this is seldom necessary in the case of your clutch because the amount of work

it is called upon to do is small as compared with many other cars of the same type, due principally to the power and flexibility of the engine.

Clutch Leather Expanders—In order to ensure easy engagement of the clutch and to provide means for slipping it when such action becomes necessary, the clutch is fitted with six clutch leather expanders. These expanders are placed under the clutch leather and present six slightly raised points of contact; they function to prevent the clutch from taking hold too quickly and they therefore act as a safeguard against sudden strains damaging other parts of the transmission mechanism.

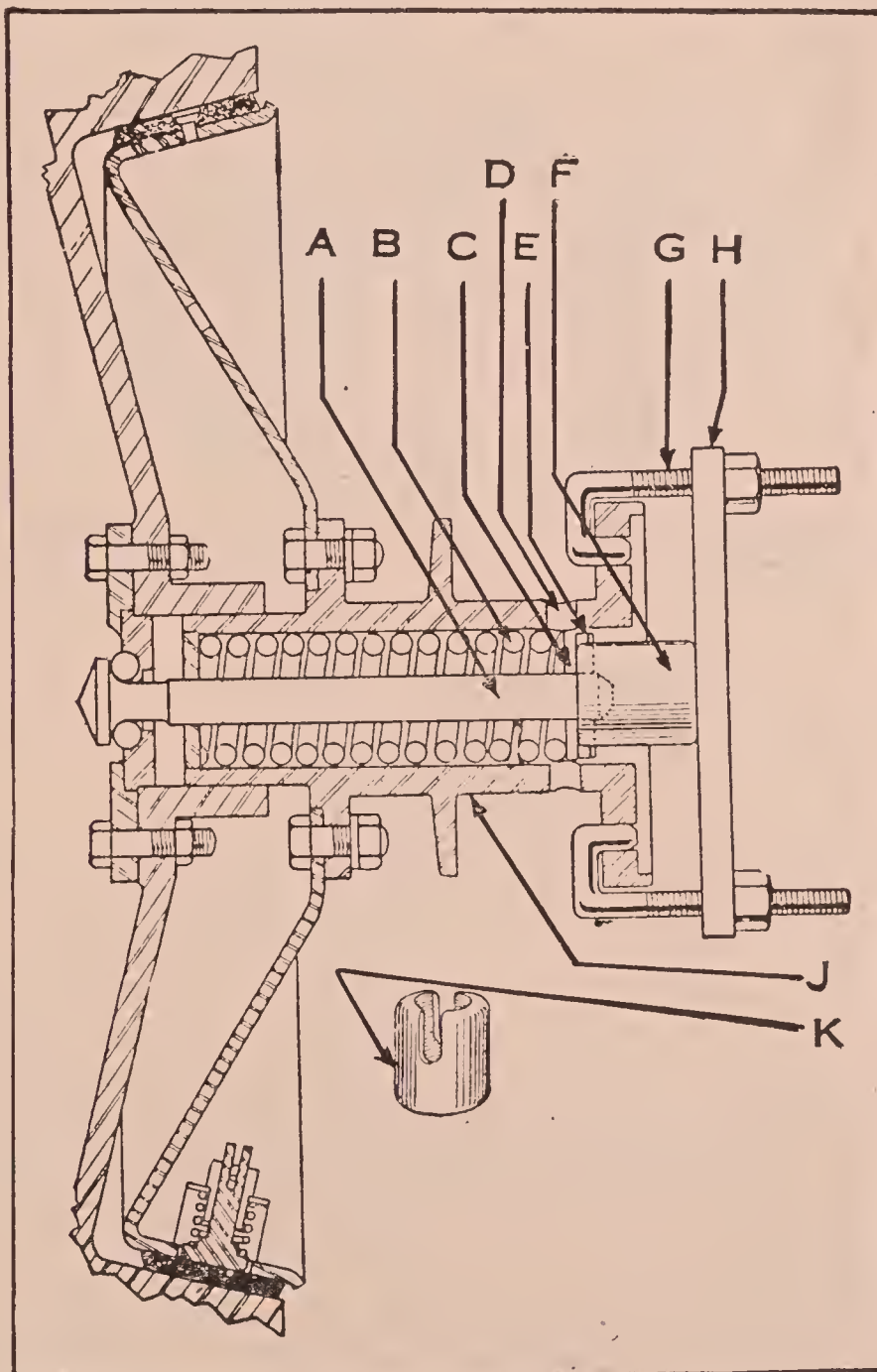


Fig. 21. Removing Clutch Spring

- A. Clutch spring tension rod
- B. Clutch spring
- C. Clutch spring retainer
- D. Clutch spring retainer pin hole
- E. Clutch spring retainer pin

- F. Slotted pipe coupling
- G. Hook bolt
- H. Steel bar
- J. Clutch hub
- K. Slotted pipe coupling

A Slipping Clutch—A slipping clutch can readily be detected by running the car in high gear, throttling down to six or seven miles (10 km.) an hour, and gently applying either the foot or the hand brake, the clutch not being disengaged; if the engine shows a marked tendency to stop, or labors heavily, the clutch is holding; if the speed of the engine is but little affected by this treatment, the clutch is not holding properly and should be adjusted or cleaned.

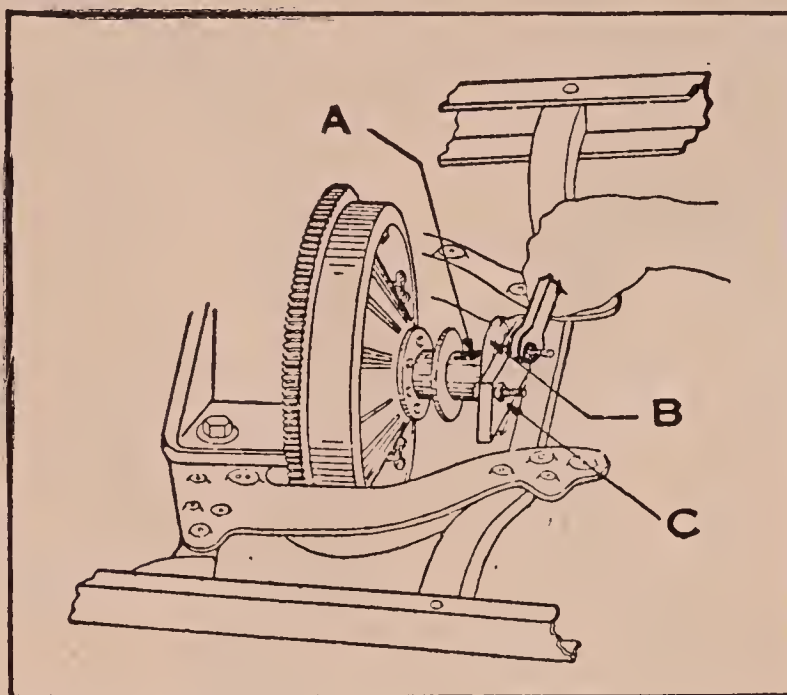


Fig. 22. Removing Clutch Spring

A. Clutch spring retainer pin hole B. Clutch hub C. Steel bar

Slipping of the clutch is caused by a badly worn clutch leather (lining), oil or grease on the leather, improperly adjusted clutch pedal or clutch leather expanders, riding the clutch pedal, or a broken clutch spring.

Accumulations of dirt and grease on the front (squared) end of the clutch gear shaft (5, fig. 26) on which the clutch hub (7, fig. 19) slides will cause slipping, also. Such accumulations will set up a gummy condition of the surfaces that will prevent the clutch from seating fully in the fly-wheel and slipping will result. The remedy is washing with gasoline or kerosene from time to time, as directed in ROUTINE CARE, and the application of a few drops of engine oil.

Harsh Clutch Action—Harsh clutch action—too rapid engagement—is caused by improperly adjusted clutch expanders, a dry, burned, or glazed clutch leather, or because the latter has a gummy coating that causes it to adhere to the fly-wheel.

In such a case, adjust the clutch expanders correctly. If this does not remedy the condition, wash the clutch leather with gasoline and, when dry, apply neat's-foot oil to soften it.

Worn Clutch Leather—It is best to have a worn clutch leather replaced by a reliable repair shop. However, if this is not convenient, proceed as follows:

Remove the clutch control mechanism and the transmission (see page 77). Remove the clutch spring, using for this purpose a tool similar to that illustrated in figure 21. Place the slotted pipe coupling shown in figure 21 between the steel bar of the tool and the clutch spring, so that the clutch spring tension rod will pass through the hole in the pipe coupling and the clutch spring retainer pin will be in the slotted portion; see figure 21.

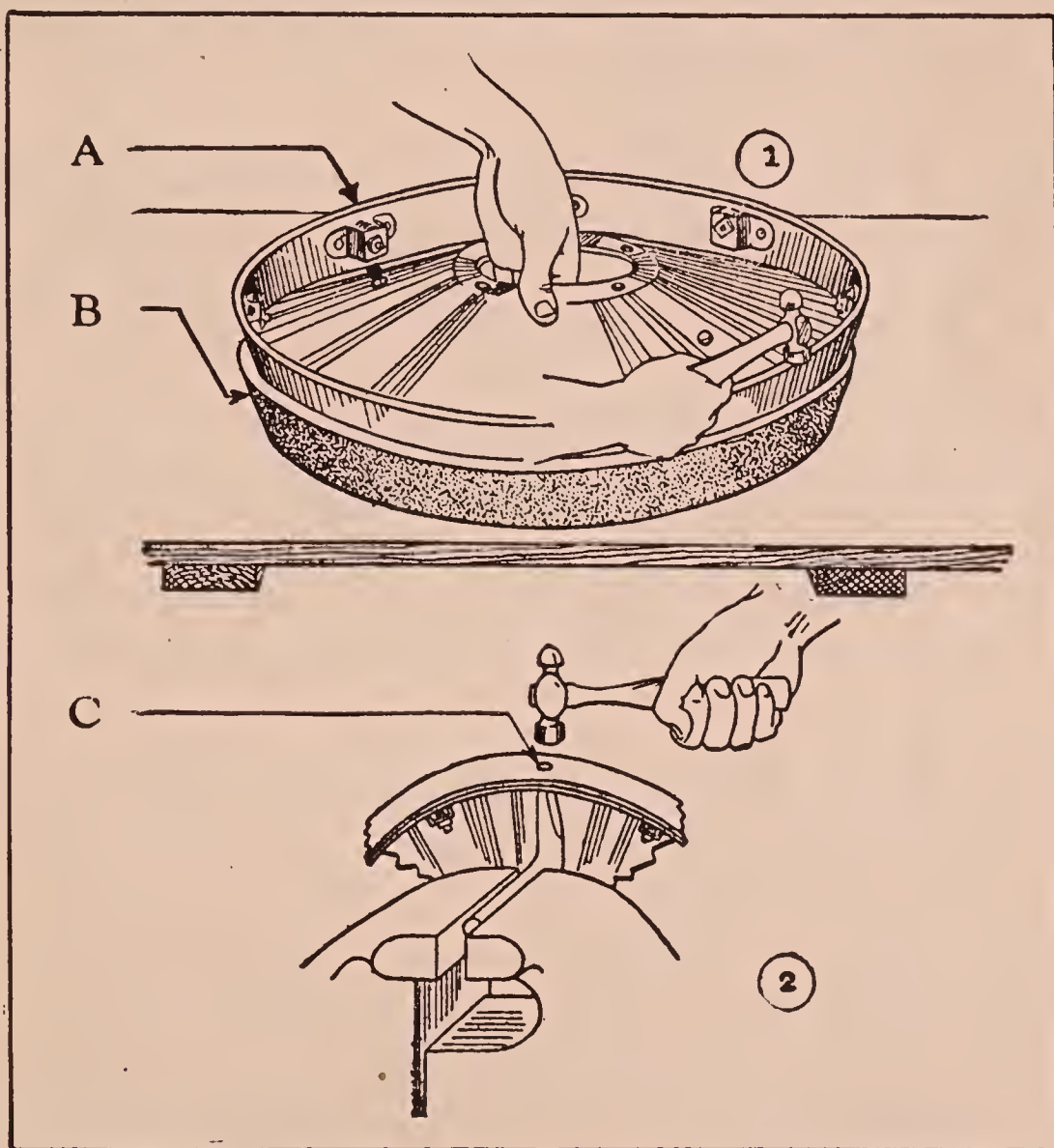


Fig. 23. Fitting a New Clutch Leather

1. Inserting clutch cone into clutch leather

2. Riveting clutch leather

A. Clutch cone

B. Clutch leather

C. Clutch leather rivet

Alternately tighten each of the nuts of the tool until the clutch spring has been compressed sufficiently to permit the clutch spring retainer pin being driven out through the hole in the clutch hub. The clutch can now be removed.

These operations are reversed in replacing the clutch and the clutch spring. Be sure to place the clutch spring retainer washer between the clutch spring and the slotted pipe coupling and to keep the slots of the latter in a

vertical position before applying pressure to the clutch spring. The clutch spring must be sufficiently compressed to permit inserting the clutch spring retainer pin through the hole in the clutch hub into the hole in the clutch spring tension rod, when the tool can be removed.

Fitting the New Lining—Whilst removing the old clutch leather from the clutch cone by cutting the rivets which hold it in place, soak the new leather in water, so that it will stretch slightly. Then slip it over the clutch cone, as shown in figure 23, resting the smaller diameter of the leather on a perfectly flat surface. Press the clutch cone evenly into the leather, slightly tapping the edge of the clutch cone on its larger circumference, until it is completely within the leather.

Punch or drill holes in the clutch leather to correspond with those in the clutch cone and then countersink them. Insert the rivets as shown in figure 23. Sink the rivet heads below the surface of the leather by slipping the split ends of the rivets over a chisel and tapping them with a light ball-headed hammer or similar tool; the rivet heads must be slightly below the surface of the leather. Spread the split ends of the rivets as much as possible.

Oil or Grease on the Clutch Leather—Accumulations of oil or grease on the clutch leather can be readily removed by washing with gasoline, using a stiff bristle brush and a syringe. This operation can be facilitated by holding the clutch disengaged by means of a stick placed between the clutch pedal and the front of the front seat and the clutch then turned by hand to reach all its parts. Wipe the clutch leather dry with a clean cloth before removing the stick.

Fullers' earth is sometimes sprinkled on the clutch leather to prevent slipping caused by oil or grease; it is best, however, to wash the leather. Under no circumstances use resin, powdered sulphur, or other similar materials, as they injure the clutch leather and may even entail its replacement.

Clutch Leather Expanders—Improperly adjusted clutch leather expanders may cause slipping. In such a case, turn each expander nut from the left to the right until it just touches the clip in which it is mounted, and then give it one-half a turn in the opposite direction; unscrewing the clutch expander nut in this manner permits the expander plunger to function properly under the clutch leather.

Every care must be exercised that the same adjustment is made on each clutch leather expander, as unequal adjustment will cause the clutch to seat unevenly in the fly-wheel. Such a condition causes the leather adjacent to the too tightly adjusted expander to burn, due to the excessive friction thus caused at this point; it also causes the clutch to squeak or rasp in engaging.

Clutch Pedal Adjustment—If the clutch pedal is adjusted so closely as to strike the toe-board before the clutch is fully engaged, the clutch will slip. This difficulty can be overcome by loosening the adjusting-screw (4, fig. 19), and moving the clutch pedal to a position where it will not quite touch the

bottom of the toe-board when the clutch is engaged, securely locking it in this position by tightening the adjusting-bolt.

Broken Clutch Spring—If, when the clutch is slipping badly, no resistance is felt when the clutch is disengaged, or if the clutch pedal does not return to the engaged position when the foot is removed, in all probability the clutch spring is broken; a new clutch spring, therefore, should be installed (see instructions for removing the clutch under **Worn Clutch Leather**).

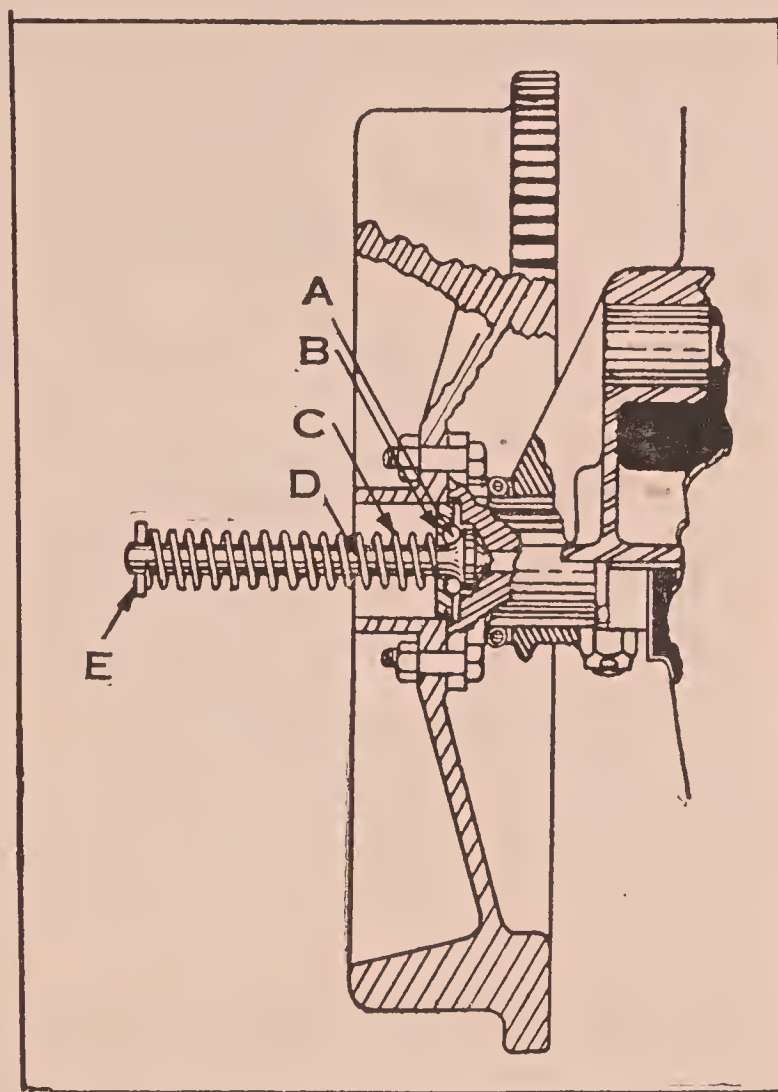


Fig. 24. Clutch Spring

- | | |
|-------------------------------|------------------------------|
| A. Thrust bearing ball | C. Clutch spring |
| B. Thrust bearing | D. Clutch spring tension rod |
| E. Clutch spring retainer pin | |

Clutch Release Bearing Lubrication—It is important that the clutch release bearing have frequent lubrication. This part consists of a hollow bronze casting fitted with wooden plugs through which the oil exudes to the frictional surface, the interior of the casting serving as an oil reservoir.

The lubricant is supplied by hand, by means of an oil can or oil syringe, through an oil pipe (10, fig. 19) leading to the oil reservoir.

Riding the Clutch Pedal—Driving with the left foot resting on the clutch pedal—known as riding the clutch pedal—should be avoided. This

practice results in unnecessary wear of the clutch lining and, particularly, of the clutch release bearing, and causes the latter in a short time to become worn and noisy. The clutch tends to slip, also, because of the slight—though unconscious—pressure applied to it by the driver's foot.

Due to the nature of the clutch construction and the difficulties involved in its assembly and disassembly without more or less special tool equipment, it is most inadvisable for the car owner to attempt such work himself unless he is a highly skilled mechanic; the manufacturer urges that it be entrusted to a well-equipped shop.

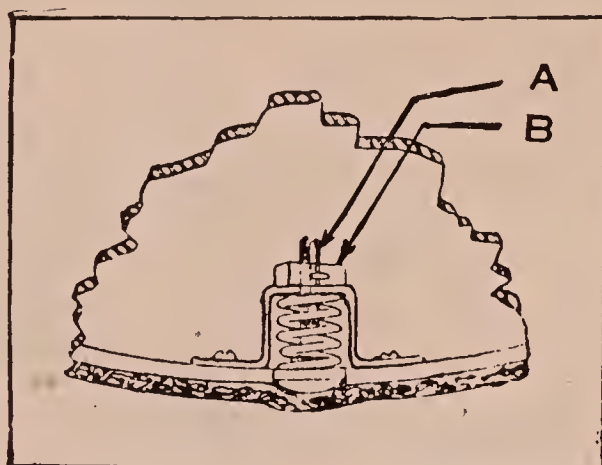


Fig. 25. Clutch Leather Expander

- A. Clutch leather expander plunger
- B. Clutch leather expander adjusting-nut

CHAPTER III

THE TRANSMISSION

Why the Transmission is Necessary—Because of the inability of an internal combustion engine to start under a load, that is, to set the car in motion simultaneously with the starting of the engine, it is necessary to interpose between the engine and the final drive to the rear wheels some form of gear reduction apparatus that will permit the engine to operate at a high rate of speed and the car at a low rate, or vice versa; or in any combination of these two conditions. In addition to this, it is necessary to vary the speed of a motor car to suit road conditions or to meet the whims of the driver, and whilst this condition can be met to a certain extent by varying the speed of the engine, other means must be resorted to since this in itself does not suffice in actual practice. Furthermore, it must be remembered that although a gasoline engine is capable of operating over a very wide range of speeds, it develops only a small proportion of its power whilst running most slowly; its maximum output occurs at its highest rate of speed or very nearly so.

A device that meets all these requirements is to be found in the automobile change-speed gear or transmission. There are a number of forms of this mechanism employed by various makers, but the one in practically universal use is the three speed, sliding gear, selective type—the type fitted to your car.

The Speeds—When low speed is in use, the greatest amount of power is transmitted to the rear wheels, for the engine is then running at a high rate of speed and the car at a low one. It is used for starting the car and for unusually steep hills, deep mud, sand, snow, etc., in short, whenever the maximum power is required.

Second speed is an intermediate speed between low and top. With it engaged, the engine runs a little more slowly than on first and the rear wheels—and hence the car—more rapidly, but with less power. Second speed is brought into use in driving when negotiating hills or heavy going that are too much for high.

The greatest car speed, but the least engine speed, is had on third, and therefore the least power; it is the normal gear for ordinary running, such as not oversteep grades, in traffic, and the like. Third or “top” is sometimes termed “direct drive,” or “direct on third,” for the power is then transmitted from the engine to the propeller shaft, and thence to the rear axle, without passing through any of the countershaft gears. It should be used at all times whilst running unless road or traffic conditions make the use of a lower gear necessary.

Reverse, of course, is for running backward. As it is somewhat more powerful than first speed, a very heavy pull that can not be made even on first can sometimes be made on reverse.

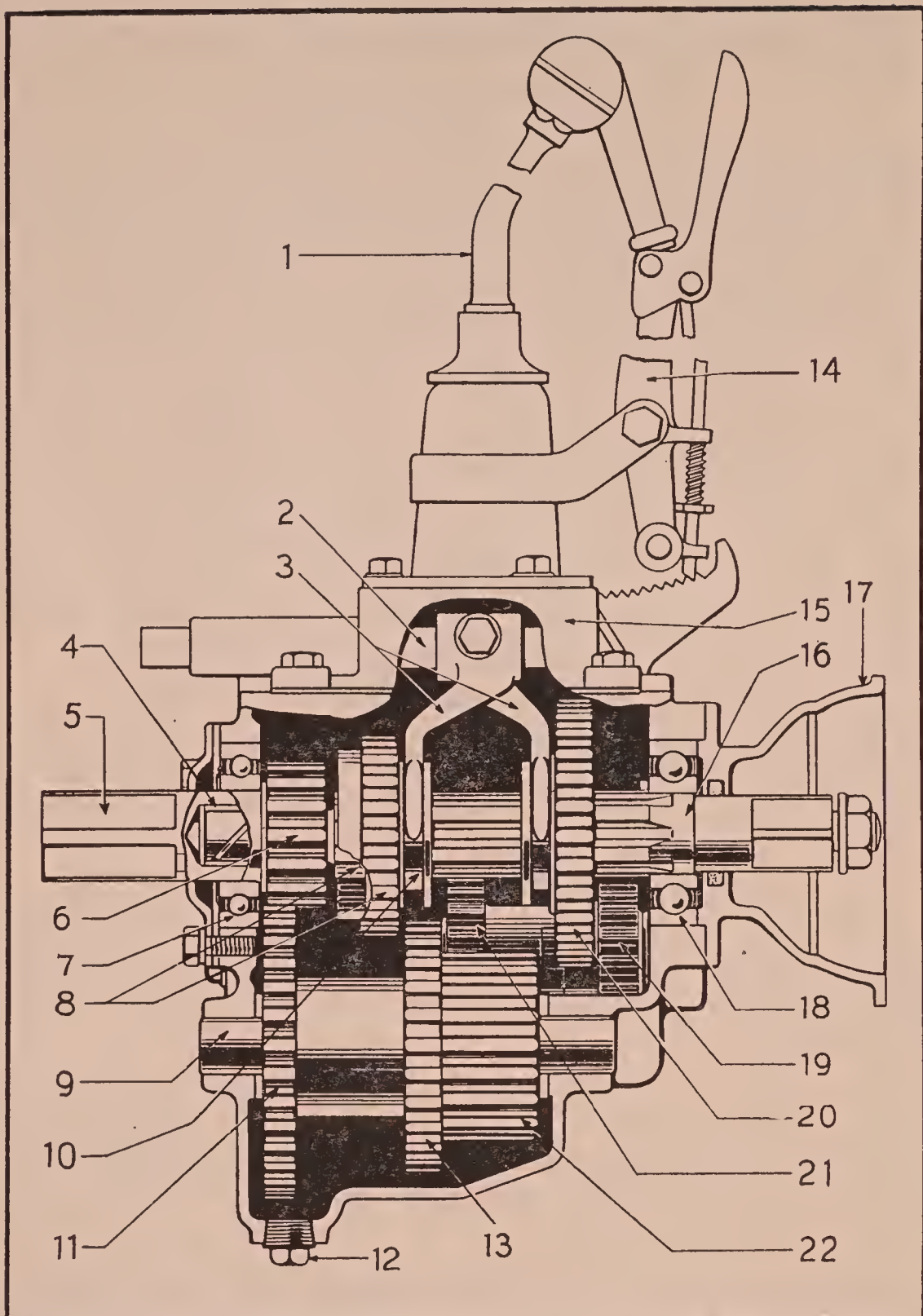


Fig. 26. Transmission

- | | | |
|--------------------------------------|-----------------------------------|---------------------------------------|
| 1 Gearshift lever | 9 Countershaft | 18 Transmission shaft rear bearing |
| 2 Gearshift rod | 10 Gearshifter collar | 19 Reverse idler gear |
| 3 Gearshifter forks | 11 Countershaft gear | 20 Reverse and low speed sliding gear |
| 4 Transmission shaft front bearing | 12 Drain plug | 21 Reverse idler shaft driving gear |
| 5 Clutch gear shaft | 13 Countershaft second speed gear | 22 Countershaft low speed gear |
| 6 Clutch gear | 14 Brake hand lever | |
| 7 Clutch gear bearing | 15 Transmission cover | |
| 8 High and second speed sliding gear | 16 Transmission shaft | |
| | 17 Universal joint ball-socket | |

Care of the Transmission—A transmission of the type described above requires attention mainly in the matter of routine care. The very simplicity and compactness of its construction are the factors that make it more desirable from the owner's point of view than transmissions employed in other and similar makes of cars. The car owner will find these qualities especially valuable when repairs or adjustments are made, for they permit large economies in labor and therefore in labor charges.

Draining the Oil—After cleaning the combined filler and level plug (14, fig. 4), remove it and the drain plug (12, fig. 26). When all the oil has drained out, replace the drain plug and pour 2 quarts (2 litres) of gasoline or kerosene through the filler plug hole into the transmission case.

Run the engine for a few minutes, thus circulating the gasoline or kerosene throughout the case; jack up one of the rear wheels and shift the various gears, running for a minute or two on each.

Again remove the drain plug and, when all dripping has ceased, securely replace it and fill the transmission to the level of the filler plug hole with transmission oil (see chapter III, part one, for oil specifications); securely replace the filler plug.

Filling with Oil—Very carefully remove all dirt from the combined level and filler plug and pour sufficient oil into the opening to overflow; securely replace the plug and wipe the surplus oil from the side of the case.

Gearshift Locks—Small plungers, held in engagement with grooves in the gearshift shafts by springs, lock the sliding gears in their respective positions—neutral, low, etc.; they are accessible by removal of two plugs in the transmission case cover. Their function is to ensure the full width of the teeth of each gear being held in contact with the full width of the teeth of its companion gear; if less than the full width were used, the wear, being then distributed over a smaller surface, would be proportionately greater.

If a gear persistently slips out of mesh whilst the car is running, it may be because of worn lock plungers or gearshift forks, and general looseness and wear, such as of the gear teeth, etc. If the former, a temporary repair may possibly be made by inserting washers between the upper ends of the lock springs and the plugs that hold them in place, but the one sure cure is replacement of the worn parts; if the gearshift forks are at fault, replacement is the only remedy.

Removing the Transmission—Remove the floor and toe boards, and disconnect the rod running from the hand brake lever to the brake cross shafts (mounted on the frame crossmember close to the rear end of the frame). Remove the bolts (F, fig. 27) from the universal joint housing and those in the clutch hub (7, fig. 19) immediately to the rear of the clutch release bearing (12, fig. 19), as well as the two holding the front end of the transmission to its support arms (8, fig. 19). Lift the front end of the transmission so as to slip the universal joint off the front end of the propeller shaft, when the transmission can be lifted out of the car; or it can be dropped and slid out.

As a general thing, it is most inadvisable for the average car owner to undertake extensive repair operations of this nature unaided by skilled help and he is, therefore, requested, in the event of such repair work becoming necessary, to entrust his car to a reputable repair shop.

In gearshifting apply the following simple rule: Never, under any circumstances whilst the engine is running, or the car in motion and the engine at rest, move the gearshift lever without first having disengaged the clutch, holding the clutch in this position until the gearshift lever is in one of the speed positions or in neutral.

CHAPTER IV

THE UNIVERSAL JOINT AND PROPELLER SHAFT

The universal joint consists of two yokes (fork-like pieces) held at right angles to each other by means of the two universal joint rings; it is encased in a ball-shaped housing which completely prevents the entrance of road dirt, etc. Its lubrication, and that of the bushing close to the front end of the propeller shaft, is ensured in an ingenious manner by taking advantage of the leakage of oil past the transmission shaft rear bearing.

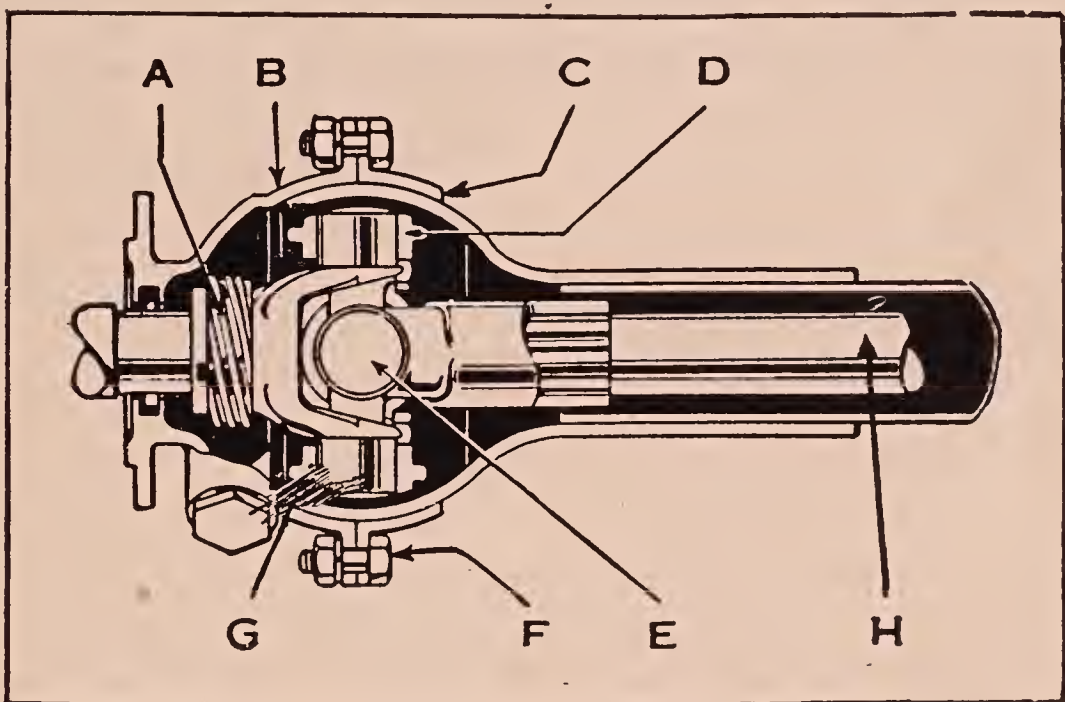


Fig. 27. Universal Joint

- | | |
|---|------------------------------|
| A. Speedometer driving gear | E. Universal joint pin |
| B. Universal joint ball socket | F. Ball retainer collar bolt |
| C. Universal joint ball retainer collar | G. Universal joint ring |
| D. Universal joint ring | H. Propeller shaft |

The Propeller Shaft Bearings—The rear end of the propeller shaft is mounted in two large ball bearings, one of these being of the double row type, that is, two rows of balls are employed instead of the more usual one, thus ensuring greater strength and longer life at this point.

The Torque Tube—The propeller shaft and its bearings are enclosed in the torque tube, thus protecting these parts against the entrance of foreign matter. In addition to this, the torque tube does what its name implies—it compensates torque reaction, that is, it prevents the rear axle housing from rotating around the axle shafts when power or the brakes are applied—as when the car is driven or the brakes used.

Care—The universal joint and other parts of the propeller shaft require but little attention. Cleanliness, periodical tightening of the various bolts

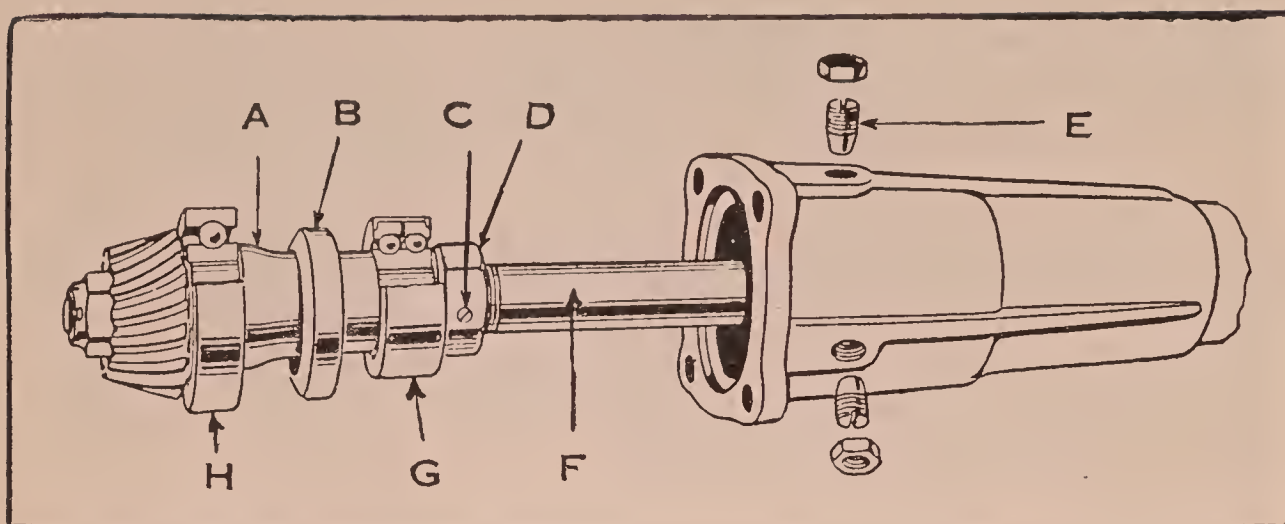


Fig. 28. Propeller Shaft (Bevel Pinion Shaft) Bearings

- | | |
|------------------------|--|
| A. Bearing spacer | E. Lock sleeve lock screw and lock nut |
| B. Lock sleeve | F. Propeller shaft |
| C. Lock nut lock screw | G. Bevel pinion front bearing |
| D. Lock nut | H. Bevel pinion rear bearing |

and nuts, and ensurance of lubrication by keeping the transmission filled to the right level with oil are all that is needed to,obtain satisfactory service and freedom from wear.

CHAPTER V

REAR AXLE

The Differential—In rounding a turn, it is obvious that the wheel on the inside has the shorter path to follow. In wagon construction, for example, all the wheels are free to turn on their axles and they therefore automatically accommodate themselves to the different distances they have to cover; hence, the inside wheels rotate a fewer number of times (cover a shorter distance) than those on the outside.

This is not true of the rear wheels of a motor car, although it is of the front ones; in the former case they are keyed fast to the axle shafts and must turn with them. As a result, in rounding a turn one wheel would slide or scrape around were not some device employed to eliminate this action by automatically decreasing the speed of the inside wheel.

This requisite is met through the use of the differential, which causes one rear wheel to rotate a greater number of times than the other. Thus, when a car is running along a straight stretch of road, both rear wheels roll at the same rate of speed—or approximately so—and cover the same distance, but when turning a corner the inside wheel rotates at a slower rate and therefore covers a shorter distance. It is this device, also, that permits of one of the rear wheels, when it is jacked up, being driven whilst the other remains at rest.

Briefly, the differential enables the rear wheels simultaneously to turn at different rates of speed whenever this may be necessary.

Mud, Snow, Etc.—A similar action takes place when the rear wheels are in mud, snow, sand, etc., or on ice, but in these cases the wheel in the mud, snow, or the like, being the easier to turn because of the slippery nature of the material it is running in, receives all the power and therefore rotates without driving the car. It is for this reason that it is necessary, in driving through mud, snow, or other slippery material, to use chains or non-skid tyres—preferably the former—to prevent slipping or skidding of the rear wheels.

Care—The rear axle requires but little care except with respect to lubrication, periodical tightening of the various bolts and nuts, and cleaning. The instructions in part two, relative to routine care operations, should be followed as closely as circumstances permit, particularly regarding lubrication and frequent changing of the oil.

Changing the Oil—Remove the plug from the bottom of the axle housing, draining it. When all dripping has ceased, replace the plug and pour 1 to 2 quarts (1 to 2 litres) of kerosene or gasoline into the axle through the combined filler and level plug hole on the right, rear side of the axle housing. Jack up one of the rear wheels and run the differential for two or three minutes by means of the engine and one of the speeds, and then drain again. Securely

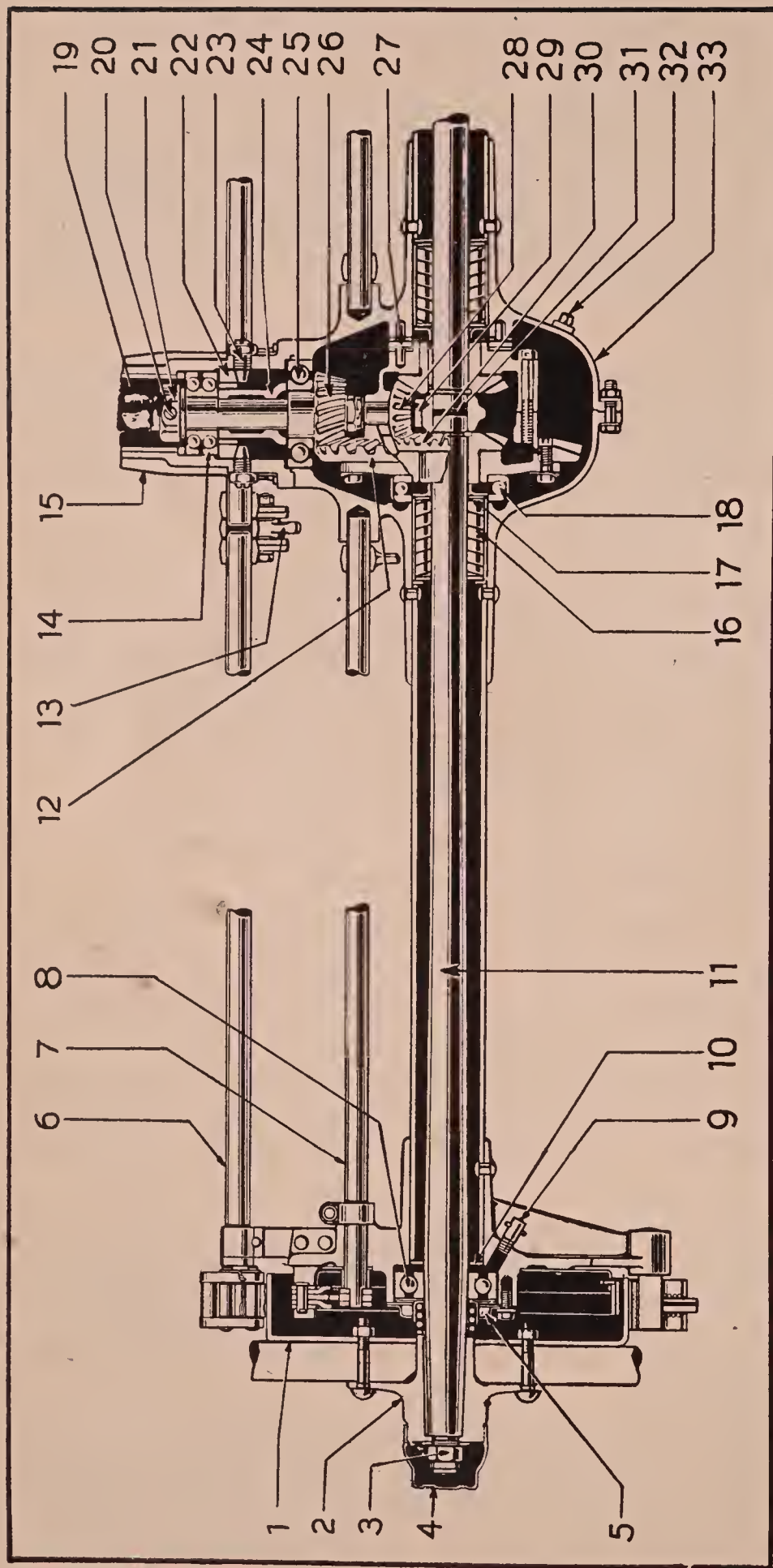


Fig. 29. Rear Axle

1	Brake drum	14	Propeller shaft bearing	19	Propeller shaft lock-nut	27	Differential thrust washers
2	Wheel hub	15	Torque tube	20	Propeller shaft lock-sleeve	28	Differential pinion
3	Axle shaft nut	16	Differential bearing	21	Bearing lock-sleeve	29	Differential spider
4	Hub cap	17	Differential bearing spacer	22	Lock-sleeve screw	30	Differential side gear
5	Wheel bearing felt washer	18	Differential thrust bearing	23	Bearing spacer	31	Axle shaft thrust washer
6	Foot brake operating shaft			24	Propeller shaft bearing	32	Oil filler plug
7	Hand brake operating shaft			25	Bevel pinion	33	Axle housing
8	Wheel bearing lubricator			26			
9	Wheel bearing lubricator						
10	Axle shaft oil retainer						
11	Axle shaft						
12	Bevel gear						
13	Foot brake equalizer						

replace the drain plug and fill to the height of the filler hole with transmission oil and replace and tighten the filler plug.

Filling with Oil—Clean the filler plug and the adjacent parts of the axle housing and remove the plug. The filler plug hole indicates the level to which to fill the rear axle and sufficient oil should be poured into it to overflow. Securely replace the plug and wipe off the surplus oil.

Removing a Rear Wheel—Remove the hub cap. Extract the split pin and loosen the castellated nut, screwing the latter outward until its outer face projects very slightly beyond the end of the axle shaft; **do not entirely remove the nut**. Place a jack under the axle housing tube and raise the wheel clear of the ground.

Hold a bar of bronze, copper, or brass against the center of the nut and strike the bar several sharp blows with a heavy hammer. If a steel or an iron bar is used, make certain the nut is screwed far enough to the end of the axle shaft to protect the threads of the latter from injury. Avoid striking the nut directly with the hammer; if a metal bar is unavailable, use a block of hard wood. When the wheel is free, take off the nut and remove the wheel; be careful not to lose the key—the long, rectangularly-shaped piece of steel between the axle shaft and the wheel hub.

If difficulty is experienced in loosening the wheel, have someone pull outward on it whilst another person strikes with a hammer. Be careful not to pull the car off the jack.

When replacing the wheel, insert the key, tighten the nut as much as possible, and then sharply tap the hub with a block of hard wood or bar of soft metal and a heavy hammer and try to tighten the nut further. Replace the split pin (it is advisable to use a new one) and bend its ends to prevent its slipping out.

Removing the Axle—Disconnect the brake rods and the brake release springs from the brake operating levers (on the rear axle), very slightly raise the frame of the car by placing a jack under each side of the frame, close to the front side of the rear axle. Remove the bolts holding the springs to the rear axle and pull the latter backward and out from under the car. After removing the bolts and nuts that hold the transmission to its support, if desired, it can be lifted back and up and thus out of the car; or it can be dropped and slid out. To replace the axle, the above operation is reversed. Carefully enter the splined (ribbed) or front end of the propeller shaft into the universal joint. Be careful the spring clip nuts are drawn up as tightly as possible; **loose spring clips cause broken springs**.

In assembling the rear axle, one point, relative to the installation of the bearing spacers (part No. H-134, mounted between the differential bearings and the differential; 17, fig. 29), must be carefully looked to: These spacers are finished with one side flat and the other with a projection at the center. In installing them, **place the flat side against the differential (roller) bearing**, the other being in contact with the hub of the differential side gear.

Bevel Gear Adjustments, Etc.—Assembly and disassembly of the rear axle and adjustment of the bevel gears are difficult tasks, entailing a very high degree of mechanical skill and experience to ensure satisfactory results. This is particularly true of bevel gear adjusting, for if this latter class of work is badly done it is practically certain the gears will be damaged to the extent of requiring replacement. Hence, if such work becomes necessary, the manufacturer strongly urges the car owner to have it attended to by competent mechanics, rather than to attempt it himself. In the long run, it will prove more inexpensive to drive an axle in bad condition to a repair shop than to undertake repairs or adjustments without adequate knowledge and equipment.

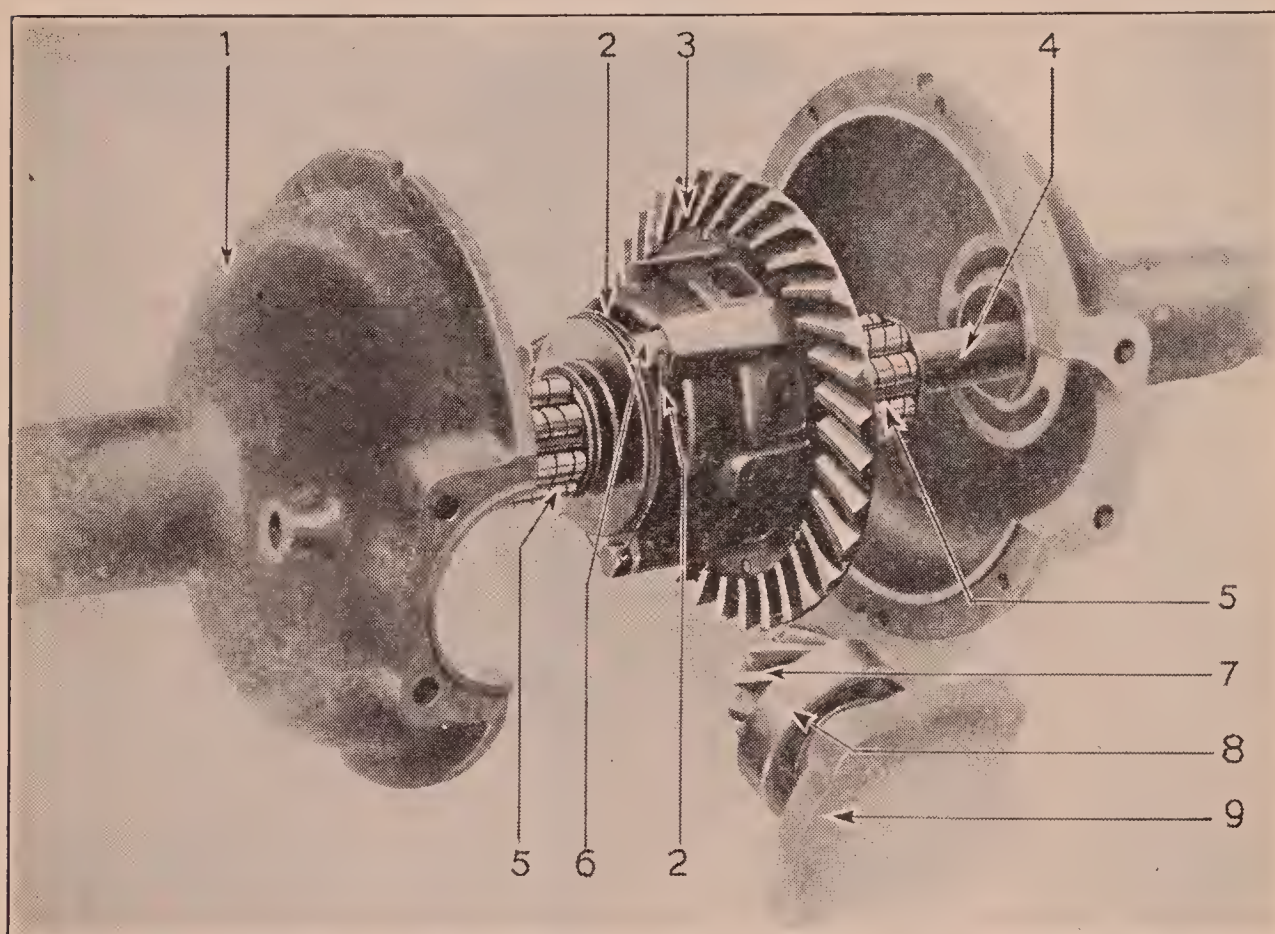


Fig. 30. Differential

- | | |
|------------------------------------|-----------------------------------|
| 1 Rear axle housing,
right half | 5 Differential bearings |
| 2 Locking-wire | 6 Differential case bolt |
| 3 Bevel gear | 7 Bevel pinion |
| 4 Axle shaft, left | 8 Propeller shaft rear
bearing |
| 9 Torque tube | |

CHAPTER VI

BRAKES

In keeping with the other high grade constructional features of your car, two complete and independent sets of brakes are fitted, there being four brakes in all. Well established standards of practice require that both sets of brakes operate directly on the rear wheels, thus applying the maximum braking effort where it is most needed and relieving the propeller shaft and other transmission parts of the very severe braking strains. Experience has clearly demonstrated that this form of brake construction is reliable and highly effective. Of the two sets of brakes, one is actuated by a foot pedal whilst the other is controlled by a hand lever.

Brakes require more or less attention because of the nature of their function. Brake linings wear in proportion to the degree and severity of their use or the correctness of their adjustment; such wear therefore necessitates proportionate compensation. This condition is especially marked during the first 250 miles (500 km.) of service, when the brakes must have more attention than later in the car's life. Like other parts of the car, the brakes wear in before assuming their final and permanent shape and condition.

With respect to the use of brakes, a very good rule to follow is never to bring one's car to a stop as quickly as possible except in an emergency. A still better rule is to reduce the use of the brakes to a minimum through careful driving, controlling the speed of the car by intelligent use of the throttle rather than through unnecessary application of the brakes.

Equalized Brakes Minimize Tyre Wear and Skidding—In brake adjusting, the utmost care must be exercised that each brake band is adjusted to hold as strongly as the other in the same set—either foot or hand, otherwise proper brake action can not be had. Moreover, tyre wear would be hastened and skidding caused were this not done; these two conditions, so far as caused by brakes, can be prevented only by equalization of the latter.

Brakes and Fuel Economy—It is obvious that the car that can be pushed by hand on a level floor only with difficulty or the one that does not coast down hill readily requires more power to propel it along a road than a free-moving one. Brakes that drag or bind because they are adjusted too closely or that do not release properly because of insufficient lubrication use up a proportionate amount of power that would otherwise be devoted to propelling the car. The degree of correctness of their adjustment and the amount of proper and regular care they receive thus have a direct effect on fuel consumption and hence on fuel economy.

Care must therefore be observed when adjusting the brakes that the brake bands do not in any degree touch the brake drums when the brakes are in the released position, and that the various pins and shafts and bearings have

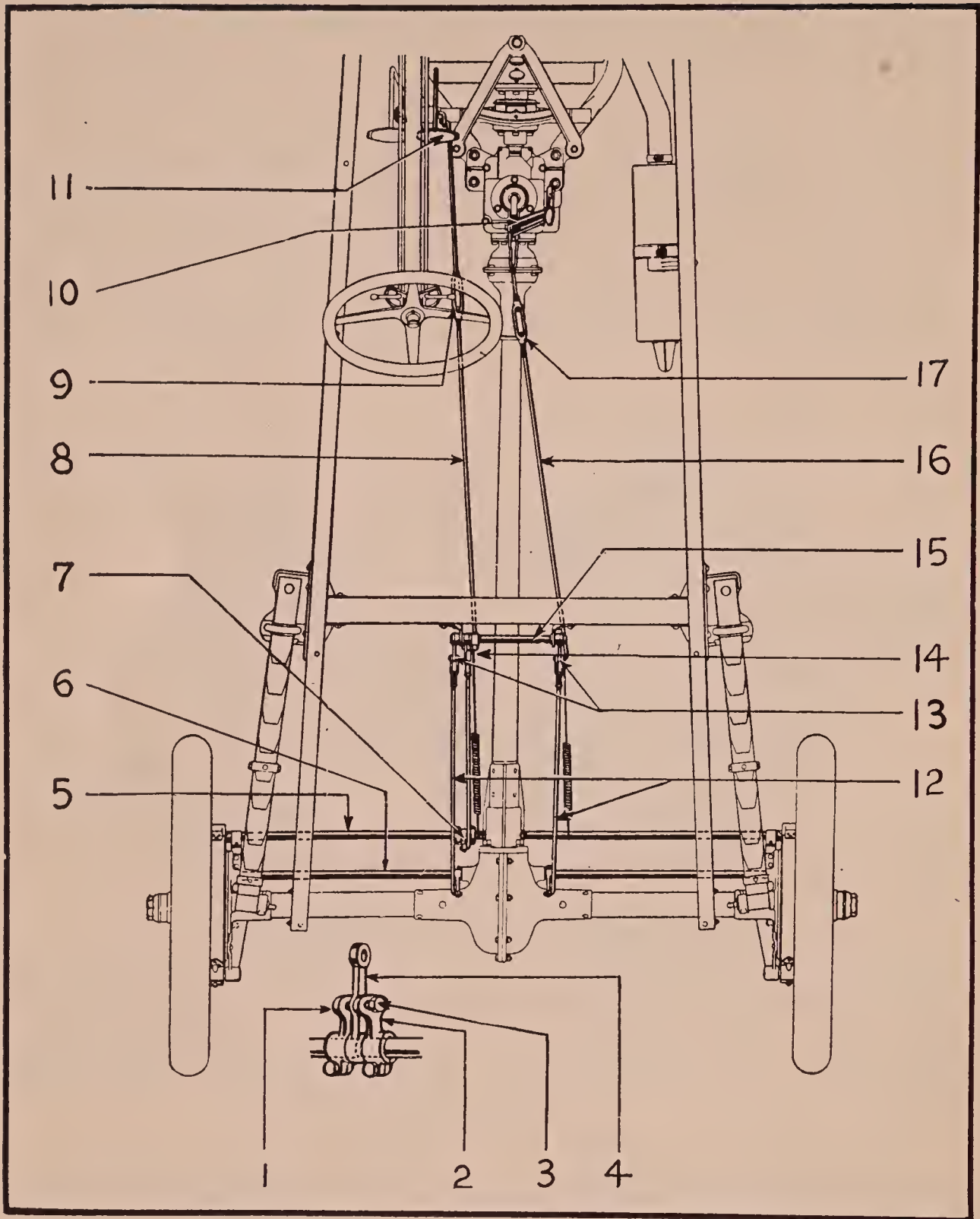


Fig. 31. Brake Mechanism

- | | |
|-------------------------------------|----------------------------------|
| 1 Foot brake adjusting-lever, left | 7 Foot brake equalizer |
| 2 Foot brake adjusting-lever, right | 8 Foot brake pull-rod |
| 3 Adjusting-lever clamp-screw | 9 Foot brake turnbuckle |
| 4 Foot brake operating lever | 10 Brake hand lever |
| 5 Foot brake operating shaft | 11 Brake pedal |
| 6 Hand brake operating shaft | 12 Hand brake rods |
| | 13 Hand brake adjusting-clevises |
| | 14 Foot brake adjusting-clevis |
| | 15 Brake cross shafts |
| | 16 Hand brake pull-rod |
| | 17 Hand brake turnbuckle |

sufficient lubrication to ensure all the parts functioning properly, particularly with respect to releasing.

Adjusting the Brakes—Slight looseness of the brakes can be compensated by means of the two turnbuckles, (9 and 17, fig. 31), under the front floor boards; of these, one adjusts the foot brake and the other the hand.

To tighten either the foot or the hand brake, loosen the lock-nuts on the turnbuckle affected, and shorten it by turning it so as to bring the ends of the brake rods closer together. Of each pair of lock-nuts, one has a right hand thread and the other a left.

After several adjustments made in this manner, the turnbuckles will have become so short that further adjustment will be impossible. In this event, lengthen the turnbuckles to their limits by turning them in the opposite direction, and then proceed as indicated below.

Foot Brake Adjustment—Additional adjustment of the foot brake is accomplished as follows:

1. Jack up both rear wheels clear of the ground.
2. At the anchor-pin adjusting-screw (5, fig. 32), insert a heavy card, about 1-32" (0.8 mm.) in thickness, between the brake lining and the brake drum. Turn the adjusting-screw inward—to the right, when facing it, at the same time moving the card from side to side, until the latter can no longer be freely moved, when the adjusting-screw should be given a half-turn to the left.
3. Loosen the lock-nut on the adjusting-clevis (14, fig. 31) of the foot brake rod and disconnect the latter at its front end from the cross shaft lever. Shorten the brake rod by screwing the adjusting-clevis inward a few turns, connect the rod to the cross shaft lever, and securely tighten the lock-nut.
4. Start the engine and speed up the rear wheels, on high gear, to 20 to 25 miles (30 to 40 km.) an hour. Apply the foot brake and note whether **both** wheels come quickly and **simultaneously** to rest. If one wheel stops more slowly than the other, loosen the clamp-screw (3, fig. 31) and push the adjusting-lever (1 and 2 fig. 31) on the slow-stopping wheel's side slightly ahead, being careful not to disturb the position of the other adjusting-lever, and securely tighten the clamp-screw. If both wheels come slowly to a stop, shorten the foot brake rod (8, fig. 31) by means of its turnbuckle (9, fig. 31).
5. Securely tighten the turnbuckle lock-nuts.

Further adjustment can then be effected by means of the turnbuckle.

Be careful not to shorten the brake rod (8, fig. 31) more than is necessary, as this would cause the brake lining to rub against the brake drums and would result in rapid wear. It should be possible quite readily to move a heavy card, say, $\frac{1}{32}$ " (0.8 mm.) in thickness, completely around the brake drum, between it and the brake lining, when the brake is correctly adjusted; a smaller clearance will cause the brake to drag or bind—the wheel will not turn as freely as it should and the brake will heat and wear rapidly.

Adjustment of the Hand Brake—The same caution with respect to equalization must be observed when adjusting the hand brake; proceed as follows:

1. Jack up both rear wheels; loosen the turnbuckle (17, fig. 31) on the brake rod connected to the hand brake lever.
2. Set the hand brakes by pulling half-way to two-thirds back on the hand brake lever.
3. Try to turn each rear wheel by hand. If either wheel can be moved, shorten the brake rod (12, fig. 31) on the loose side by means of its adjusting-clevis (13, fig. 31).
4. Release the hand brake lever and speed up the rear wheels to 20 to 25 miles (30 to 40 km.) an hour by means of the engine and high gear. Apply the hand brake and note whether **both** wheels come quickly and **simultaneously**

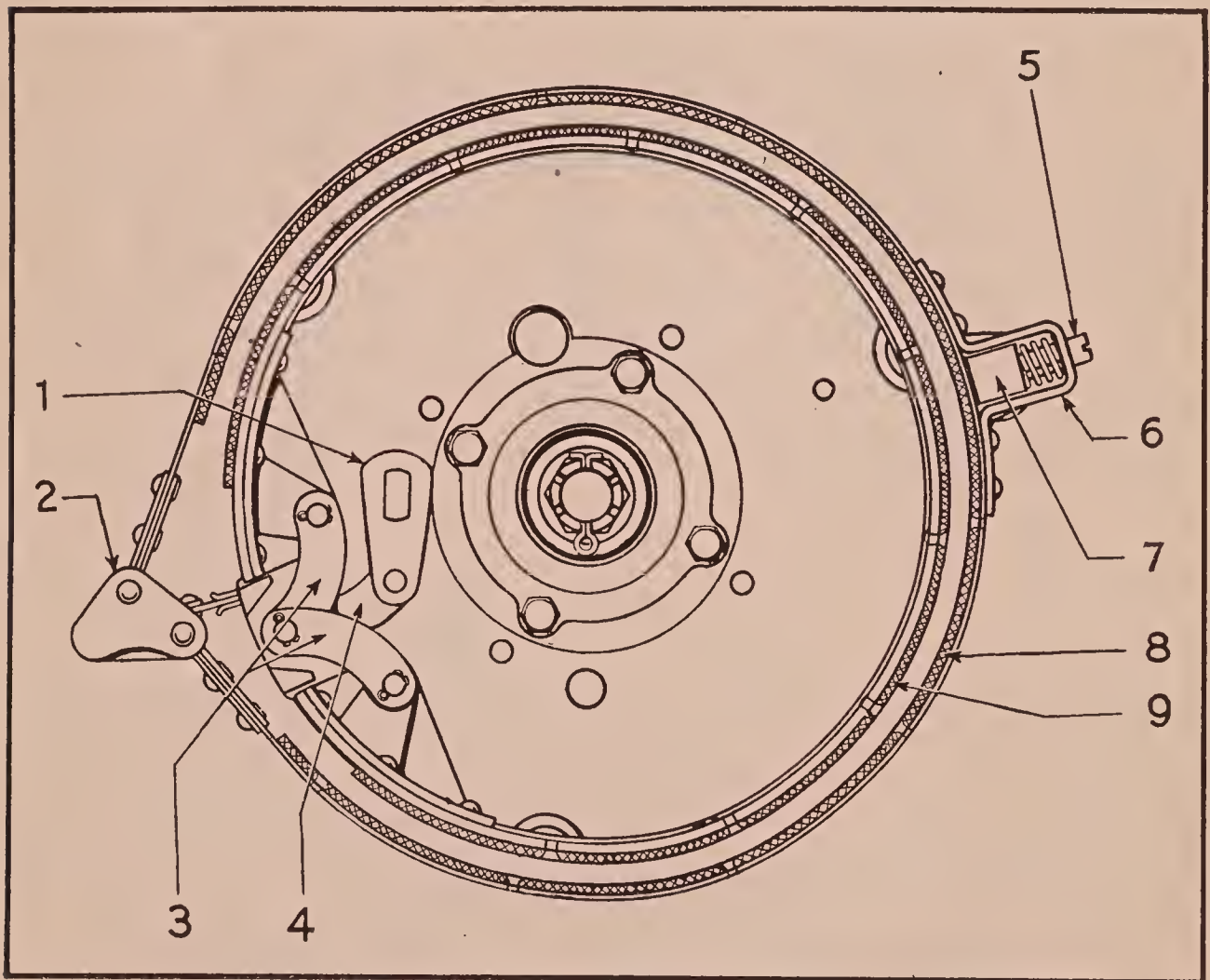


Fig. 32. Brake Bands

- | | |
|---|--------------------------|
| 1 Hand brake toggle lever | 6 Foot brake band saddle |
| 2 Foot brake toggle lever | 7 Foot brake anchor-pin |
| 3 Hand brake toggle links | 8 Foot brake band |
| 4 Hand brake toggle lever links | 9 Hand brake band |
| 5 Foot brake anchor-pin adjusting-screw | |

to rest. If one wheel stops more slowly than the other, shorten its brake rod; if both wheels come slowly to a stop, shorten both brake rods. At the conclusion of the adjustment, tighten the lock-nuts; remember that some have right hand and others left hand threads.

When the hand brake is fully set, the correct position for the hand brake lever is half-way to two-thirds toward the rear. Compensate slight looseness by shortening the turnbuckle on the hand brake rod under the front floor boards. Be careful not to tighten the hand brake too much; this would cause the brake bands to rub against the brake drums and would result in heating and rapid wear. With the hand brake lever released, it should be possible for the rear wheels to turn quite freely; if a grating sound is heard when the rear wheels are turned, the brakes are too tightly adjusted and are dragging; they should be readjusted until the dragging is eliminated.

Caution—In adjusting either the foot or the hand brakes, there is one point that must be very carefully watched: the positions of the brake cross shaft levers (15, fig. 31). When the brakes are fully released, these levers should point downward and toward the rear; if they point forward or are vertical, the brakes can not be as completely applied as is otherwise possible, for the distance the levers can then be moved in applying the brakes will be proportionately shortened and the full braking effort therefore can not be obtained. The brake cross shaft levers can be maintained in their proper positions only through correct adjustment of the foot brake bands and the adjusting clevises.

Lubrication—Follow the directions in ROUTINE CARE in every particular. All brake pins require lubrication by hand—engine oil and an oil can. The brake cross shafts are lubricated by hand, with an oil can; the operating shafts—on the rear axle—are likewise lubricated. Use plenty of oil on the brake levers and pins on the brake bands; wash these parts frequently with gasoline or kerosene and a stiff bristle brush and then lubricate them thoroughly; make a practice of applying oil to them every time they are adjusted.

Relining the Brakes—Remove the rear wheels and then the brake bands that are to be relined. Cut the rivets holding the linings to the bands and drive them out of their holes, and pull the old linings off.

In riveting the new linings in place, take care that the rivet heads are countersunk below the surface of the linings, to prevent their coming in contact with the brake drums, and that the linings are not wrinkled or puckered.

Adjust the brakes after fitting new linings, to prevent their dragging because of the increased thickness of the new linings. Frequent adjustment will be necessary until the brakes will have worked in.

Brakes not Holding—There are generally two reasons for brakes not holding properly: One, incorrect adjustment or wear, in which case proceed

as directed above; two, accumulations of grease or oil on the brake bands or drums, causing the brakes to slip. In this latter case the remedy is a thorough washing with gasoline or kerosene, a stiff bristle brush, and a syringe. In extreme cases it may be necessary to remove the wheels before washing.

So far as safety of operation is concerned, the brakes are one of the two most important parts of the car. They should, therefore, receive every consideration and attention.

Locking one or both rear wheels in attempting to make a rapid stop can not produce the desired result; it will only cause rapid wear of the rear tyres or skidding.

Equal adjustment of each set of brakes must be made before efficient brake action can be had.

CHAPTER VII

THE FRONT AXLE

Lubrication—In the course of a day's run, the various connections and bearings of the steering rods and levers are subjected to considerable movement. In addition to this, they are so exposed to road dirt that it is impossible to keep foreign matter out of their bearings and rapid wear must take place unless prevented by frequent lubrication.

Tightness of Parts—The nuts on the steering knuckle pivots, the steering knuckle tie-rod pins, as well as those holding the steering knuckle arms in the steering knuckles, should be examined from time to time to see that they are tight and that the split pins in each of these nuts are holding the latter from turning.

Front Wheel Alignment—It sometimes happens that the front wheels are not correctly aligned with one another, being too close together at the front or rear; this is known as toeing-in or -out.

In addition to making for stiff and uncertain steering, misaligned front wheels cause extremely rapid wear of the front tyres. This is due to one wheel running straight—parallel with the direction of the car's motion—whilst the other runs at an angle to it, scraping as well as rolling along the road surface. It can be readily seen that in this case the road surface grinds quantities of rubber from the tread of the tyre on the wheel affected; unless stopped, total destruction of this tyre will soon follow.

This condition is readily detected, but, unfortunately, the average driver does not notice it until it has progressed to such an extent that the front tyres are badly worn, when he makes an investigation. Periodical inspection is necessary if preventive measures are to be applied in time to save the tyres.

To align front wheels, proceed as follows:

1. Jack up the front axle to raise both wheels clear of the ground.
2. See that the front wheel bearings are properly adjusted; if loose, see page 93 for directions.
3. Adjust the demountable rim bolts to ensure the tyres running true with the wheels.
4. Remove the jacks and press the fronts of the wheels apart to take up play or looseness in the steering connections
5. With a rod of metal or wood or a piece of string, at the height of the hubs, measure the distance between the inner sides of the front wheel felloes; distance A, figure 33, should be $\frac{5}{16}$ " (8. mm.), less than B.

To adjust the distance A (item 5, above), remove the steering knuckle tie-rod pin, loosen the adjusting-end clamp-bolt (1, fig. 33), and screw the yoke outward or inward respectively to decrease or to increase A. **Securely**

tighten the clamp-bolt and replace the tie-rod pin, not forgetting the split pins.

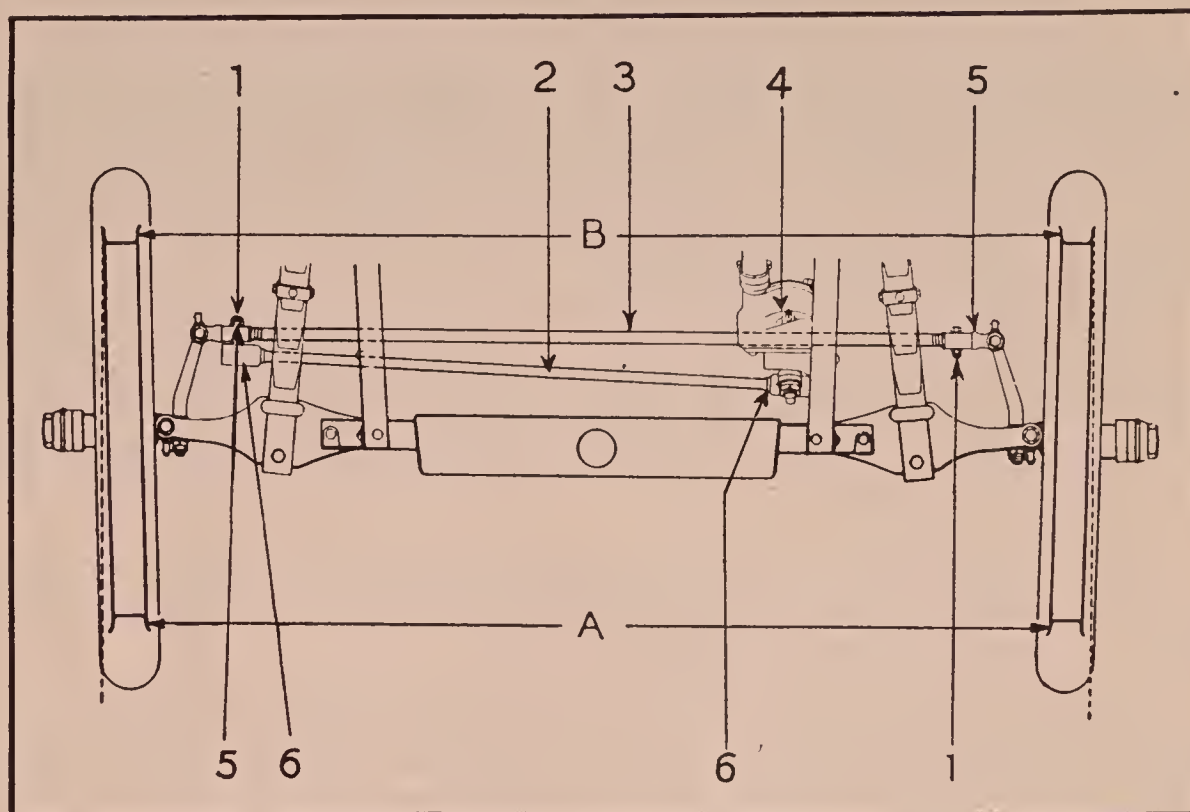


Fig. 33. Front Wheel Alignment Diagram

- | | |
|--------------------------------|------------------------------|
| 1 Adjusting-end clamp-bolt | 4 Steering gear |
| 2 Steering gear connecting-rod | 5 Tie-rod adjusting-end |
| 3 Steering knuckle tie-rod | 6 Connecting-rod ball-joints |

Stiff Steering—If steering is stiff, proceed as follows:

1. Check the wheel alignment.
2. Jack up the front axle to raise both wheels clear of the ground.
3. Disconnect the axle end of the steering gear connecting rod (2, fig. 33).
4. Adjust the steering gear end of the connecting rod to take up all looseness. It should move quite freely and smoothly when swung up and down; see page 93 for adjustment.
5. Swing the wheels from side to side. They should swing very freely; if not, disassemble the various joints, including the steering knuckle pivots, and clean and lubricate them. When reassembling these parts, tighten the pivots and pins only enough to take up looseness; extreme tightening will cause binding.
6. Inspect the balls on the steering gear lever (on steering gear) and on the tie-rod for wear; if badly worn—flat, for example, replace.
7. Inspect the steering gear:
 - (a) It should turn freely;
 - (b) The bushing in the upper end of the steering column tube should not bind;

- (c) The steering wheel hub should not bind on the steering column tube;
- (d) The steering column tube should be in line with the recess it fits into in the instrument board;
- (e) There should be about 1' (25 mm.) of play at the steering wheel rim (see page 95 for steering gear adjustment);
- (f) All moving parts should be thoroughly lubricated; force transmission oil through the steering gear and the column tube with air pressure if necessary.

Do not forget to replace the split pins in the steering knuckle pivots, steering knuckle tie-rod pins, and steering gear connecting rod; it is advisable to use new one.

Steering Gear Connecting Rod—The steering gear connecting rod is disassembled, or looseness in it is adjusted, as follows:

Remove the split pin from the steering gear end of the rod and, with a large screw driver, unscrew the large slotted plug, and then take out the spring and ball-cup. Wash the parts thoroughly with gasoline or kerosene, pack them with soft cup grease, and replace them. Screw the slotted plug in far enough to take up all looseness, but not enough to cause stiff movement; the joint should be free enough to permit of its being easily moved. Align the slot in the plug with the split pin holes and insert the split pin, spreading the latter's ends to prevent it from working out; it is always best to use new split pins. Treat the joint in the other end of the rod in the same manner.

In replacing the springs and the ball-cups in the steering gear connecting rod, it is of the highest importance that they be restored to their original positions. The spring in the joint (6, fig. 33) at the axle end — right hand end — of the steering gear connecting rod is next to the adjusting-plug—between the latter and the steering knuckle arm ball. At the steering gear end, the steering gear arm ball (7, fig. 35) is between the spring and the adjusting-plug. In other words, the springs are placed at the right hand sides of the joints.

In cars fitted with right hand steering, the opposite holds good—the springs are installed at the left hand sides of the joints.

Front Wheel Bearings—The front wheel bearings require adjustment from time to time, as well as periodical inspection, cleaning, and repacking with fresh grease. Loose wheel bearings are readily detected by grasping the upper side of the tyre and pushing back and forth against the wheel, noticing if there is any looseness at the hub, that is, between the inner side of the hub and the steering knuckle. To prevent wear in the steering knuckle pivot bearings being confused with looseness of the wheel bearings, force a chisel or similar tool between the axle yoke (the large openings at the ends of the front axle) and the steering knuckle, when any looseness that may be noticed will be in the wheel bearing itself.

Adjustment—If adjustment of a front wheel bearing appears necessary, remove the hub cap, jack up the wheel, extract the split pin from the bearing

nut, and tighten the latter sufficiently to eliminate all looseness. Take great care not to make the adjustment too tight, or the bearing will be damaged.

After making the adjustment, and before inserting the split pin in the bearing nut, rotate the wheel and let it come to rest. If the adjustment has been correctly made, the wheel will stop with the tyre valve at the bottom; the wheel should oscillate several times before finally coming to rest.

Another method is to turn the wheel until the valve stem is at the top and tighten the wheel bearing nut sufficiently to prevent the wheel from turning. Then, very slightly loosen the nut until the wheel again starts to turn and insert the split pin and bend its ends.

Pack the bearings and hub cap with clean, soft cup grease, and securely replace the cap.

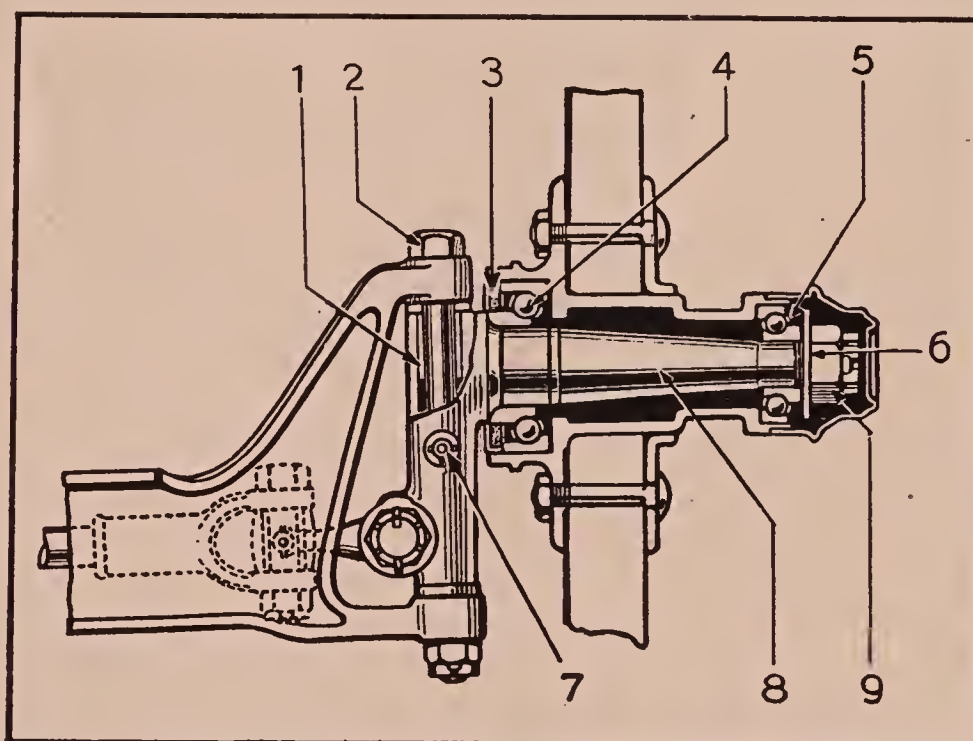


Fig. 34. Steering Knuckle and Front Wheel Bearings

- | | |
|--|--------------------------------------|
| 1 Steering knuckle pivot upper bearing | 5 Front wheel outer bearing |
| 2 Steering knuckle pivot | 6 Front wheel bearing locking-washer |
| 3 Dust washer | 7 Lubricator |
| 4 Front wheel inner bearing | 8 Steering knuckle |
| 9 Front wheel bearing nut | |

Removing the Front Wheels—The front wheels are removed by unscrewing the bearing nut, taking out the washer between it and the outer bearing, and then pulling the wheel straight out. Lift out the bearings and carefully wash them (**always wash the bearings first**), the hub cap, and the interior of the wheel hub with **clean** gasoline or kerosene to remove all dirt and old grease. After replacing the wheel, adjust the bearings as directed above, pack them, the hub cap, and the interior of the hub with **clean, soft cup grease**, and securely replace the hub cap.

CHAPTER VIII

THE STEERING GEAR

1. Jack up one or both front wheels.
2. Loosen the steering worm adjusting-plug lock-bolt (5, fig. 35) and tighten the adjusting-plug (6, fig. 35), screwing it inward—toward the steering gear housing.
3. Test the adjustment by turning the steering wheel. Continue tightening the adjusting-plug until the steering gear commences to bind—moves stiffly, when the adjusting-plug should be loosened one or two half-turns and the lock-bolt securely tightened.

Exercise the utmost care against overtightening the adjusting-plug, as this would cause stiff steering and rapid wear of the parts involved. If the adjustment is correctly made, all play can be removed from the steering gear without causing stiff action.

If all the play can not be removed by means of the adjusting-plug, remove the housing cover (1, fig. 35) and take out one or two shims (8, fig. 35), and replace the cover.

If failure still results, proceed as follows: Loosen the adjusting-plug and replace the shims. Remove the steering gear arm by taking off the nut holding it to the worm gear shaft and tapping it outward. As the worm gear is a full gear, turning the steering gear until the worm gear shaft has rotated one-quarter of a turn brings into mesh with the steering gear worm an unused quarter of the worm gear, thus eliminating the play caused by the worn part of the latter. This done, replace the steering gear arm, and proceed with the adjusting as already outlined above.

Care of the Steering Gear—With the exception of periodical cleaning and lubrication, and occasional tightening of the various bolts and nuts, the steering gear requires but little attention. Lubrication, of course, is essential; for, in addition to minimizing wear, lubrication makes for easy steering. Follow the instructions in part two, ROUTINE CARE, not neglecting such parts as the spark and throttle hand lever bearings (on the steering column tube), the spark and throttle levers (near the bottom of the steering gear), etc. Use transmission oil in the steering gear case; engine oil on the other parts.

Care of the steering gear and of the various steering rods and levers is important—vitally so. Should a bolt or a pin drop out through neglect, it may happen that the car will then be uncontrollable and its occupants endangered. The one certain preventive—periodical examination for looseness or wear—is always within your reach.

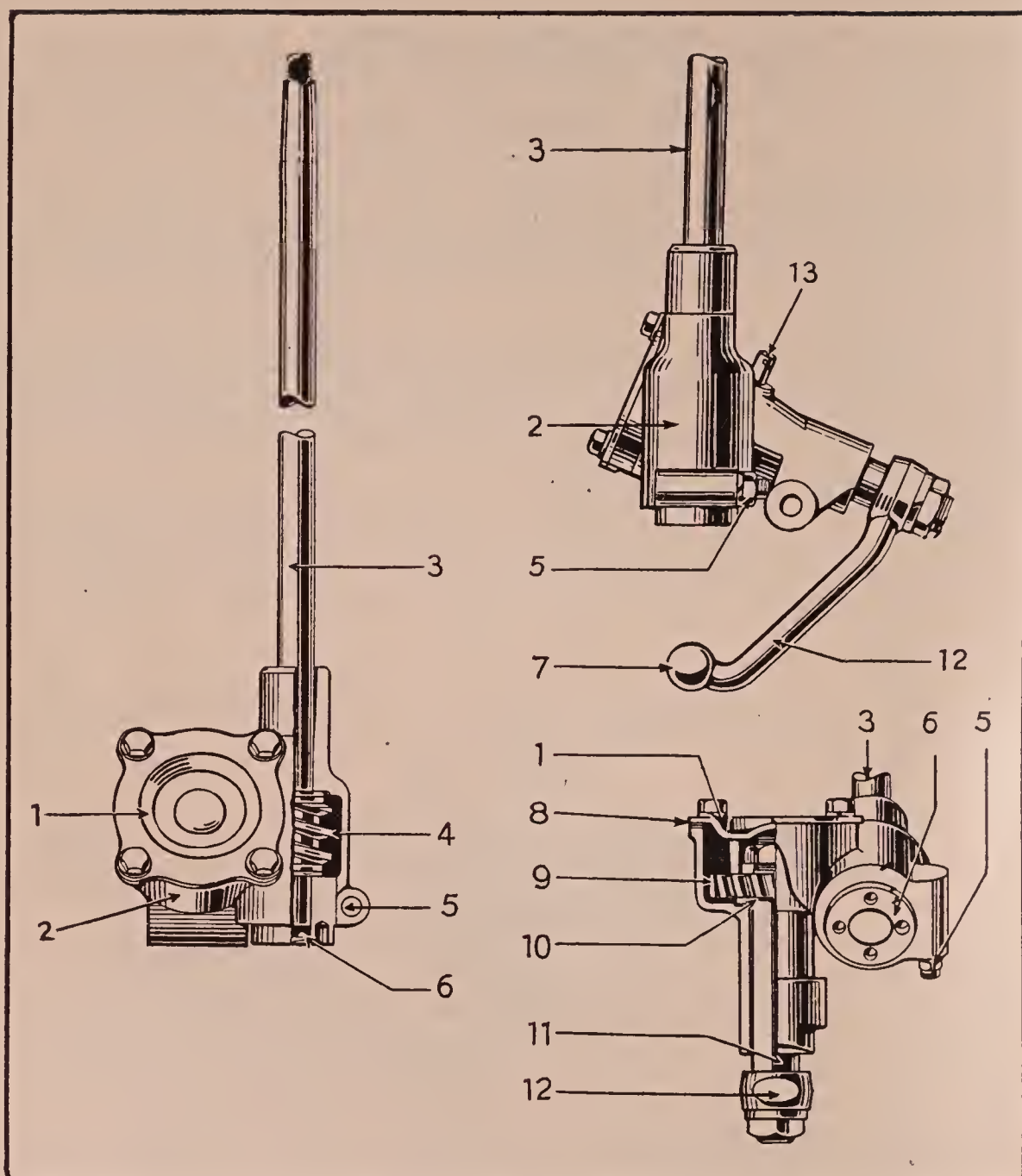


Fig. 35. Steering Gear

- | | | | |
|---|------------------------------|----|--------------------------|
| 1 | Steering gear case cover | 7 | Steering gear arm ball |
| 2 | Steering gear case | 8 | Adjusting-shims |
| 3 | Steering wheel shaft | 9 | Steering worm gear |
| 4 | Steering worm | 10 | Worm gear thrust washer |
| 5 | Adjusting-plug lock-bolt | 11 | Steering worm gear shaft |
| 6 | Steering worm adjusting-plug | 12 | Steering gear arm |
| | | 13 | Lubricator |

CHAPTER IX

THE SPRINGS

Why the Springs Require Attention—The springs of a car are subject to very severe operating conditions, due to their extremely exposed position. Being under the car and close to the road surface, they rapidly become covered with mud and grit which must be removed from time to time if they are to function unimpaired. Water, too, enters between the leaves, causing them to rust, thus aggravating this condition.

Since the leaves of the springs, in flexing, that is, in bending and straightening out, slide lengthwise on one another, the entrance of such foreign matter as mud and water causes extreme friction between the leaves. When this condition becomes acute, the leaves do not slide as freely as they should and the spring action therefore becomes stiff and hard. It thus becomes necessary from time to time to clean and lubricate the leaves, for if the stiff action is not eliminated it is quite likely the spring affected will break.

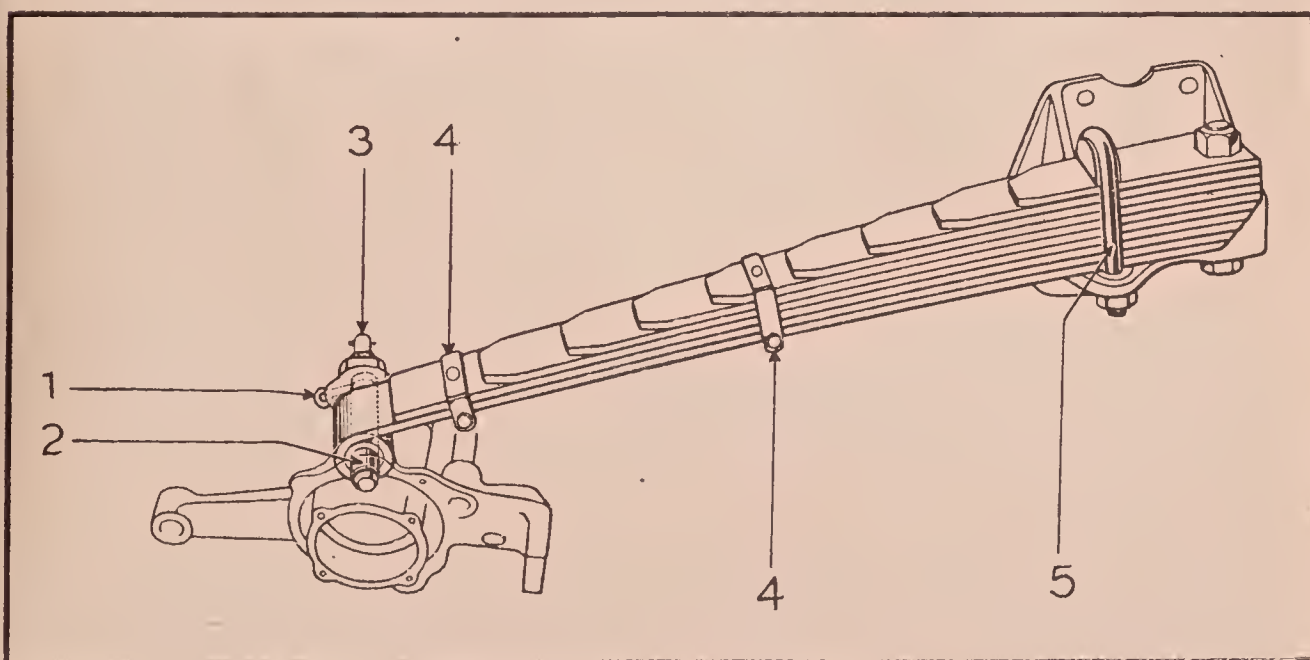


Fig. 36. Rear Spring

- | | |
|--------------------------|-----------------|
| 1 Rear spring bolt lock- | 3 Lubricator |
| ing-ping | 4 Rebound clips |
| 2 Rear spring bolt | 5 Spring clip |

Cleaning and Lubricating the Springs—When cleaning and lubrication becomes necessary, remove the spring rebound clips and jack up the frame of the car, thus separating the spring leaves; in this condition, they are readily washed by means of a stiff brush and kerosene. This operation finished, apply a liberal quantity of soft cup grease and work it between the leaves by means of a knife blade or other similar instrument.

Tighten the Clips and Bolts—Remove the jacks, replace the rebound clips, and wipe off the surplus grease. Try all the other bolts and clips with

a wrench to see that they are thoroughly tight. This last operation is highly important and should be carefully attended to, for loose spring bolts and clips are one of the most prolific causes of spring breakage.

Likewise with other parts of the car, the springs and their components require certain attention in the matter of cleanliness, lubrication, and tightness. A little effort in this respect, in accordance with the recommendations in this chapter and in part two, ROUTINE CARE, will amply compensate the car owner in the lengthened spring life and improved riding qualities that will result.

CHAPTER X

THE FRAME

The type of frame used is the pressed-steel, channel-section ("U"-shaped pieces of steel), rigidity and strength being ensured by means of numerous cross-members of the same material. This is the type of frame in almost exclusive use today.

One point with respect to its construction is particularly worthy of note: The frame tapers gradually from back to front, the rear end of the frame being wide, thus providing ample support for the coachwork (an important point in light car construction), whilst the front part is narrow to permit short turning—always a desirable quality.

Another excellent constructional feature is that the side members of the frame are straight—without the usual bends; they are therefore much stronger than other types in which the side members are inwardly bent; a more solid foundation for the entire length of the coachwork is provided, also, in this form of construction.

Little need be said regarding the care of a frame of this type, for—barring accident—very little can happen to it. However, if the car is subjected to very severe service, as over very rough roads, particularly at high speeds, some of the rivets may loosen. This condition is readily detected by the formation of rust on the metal adjacent to the loose rivet heads. It is advisable to have the rivets tightened if possible, but it is much better to replace them with new ones, as it is very difficult to make a satisfactory job in tightening loosened rivets.

CHAPTER XI

THE COOLING SYSTEM

The type of cooling system employed is absolutely positive in action under all operating conditions. The other form of water-cooling system sometimes used, known as the thermo-siphon type, whilst simpler than pump circulation, is, nevertheless, less efficient. Its advantage—in fact, its only advantage—in the eyes of some is its cheapness.

Use only Clean Water—Use only clean water in the cooling system. The particles of solid matter contained in muddy or dirty water will lodge in the very small openings between the radiator tubes, choking them and reducing the radiator efficiency. Moreover, such solid matter accumulates in the water jacket and unless removed from time to time will impede or altogether stop the flow of water through the affected parts.

Flush the Cooling System—This condition necessitates frequent draining and flushing of the entire cooling system. Open the drain cock (3, fig. 37), drain, close the cock, and fill the system with clean water. If running water is available, open the drain cock, insert the nozzle of a hose into the radiator filler spout, and run the engine, adjusting the flow of fresh water to prevent its overflowing onto the engine. Continue this for about five minutes, when the drain cock should be closed and the hose removed.

Avoid Hard Water—Water frequently contains mineral matter. If such water is used, extra precautions must be taken, for its continued use causes some of the mineral matter to form encrustations or scale on the cylinder and water jacket walls, and in the radiator, also. Such deposits in a large measure prevent the radiation of heat and therefore reduce the efficiency of the cooling system.

Removal of Scale—It frequently happens that the engine overheats for no discoverable cause. Usually the fault lies in the formation of scale, which can be readily removed as follows:

Make a saturated solution of lye (caustic soda) or ordinary washing soda and water.* Drain the cooling system, close the drain cock, and fill with the prepared solution. Run the engine with the spark retarded until the cooling water is heated to the boiling point. Let this solution remain in the cooling system for several hours, after which open the drain cock, drain, and flush with fresh, clean water, repeating the flushing several times to remove all traces of the lye or washing soda. If running water and a hose are available, flush the system by inserting the hose into the radiator water spout (with the drain cock open) and running the engine. In extreme cases it may be necessary to repeat this operation several times. **Contact of this mixture with enameled or painted surfaces will injure the finish.**

*Dissolve in 7.5 quarts (6.25 imp. qts.; 7,125 l.) of water, the capacity of the cooling system, as much lye or washing soda as can be dissolved therein; strain the mixture through cloth before using it.

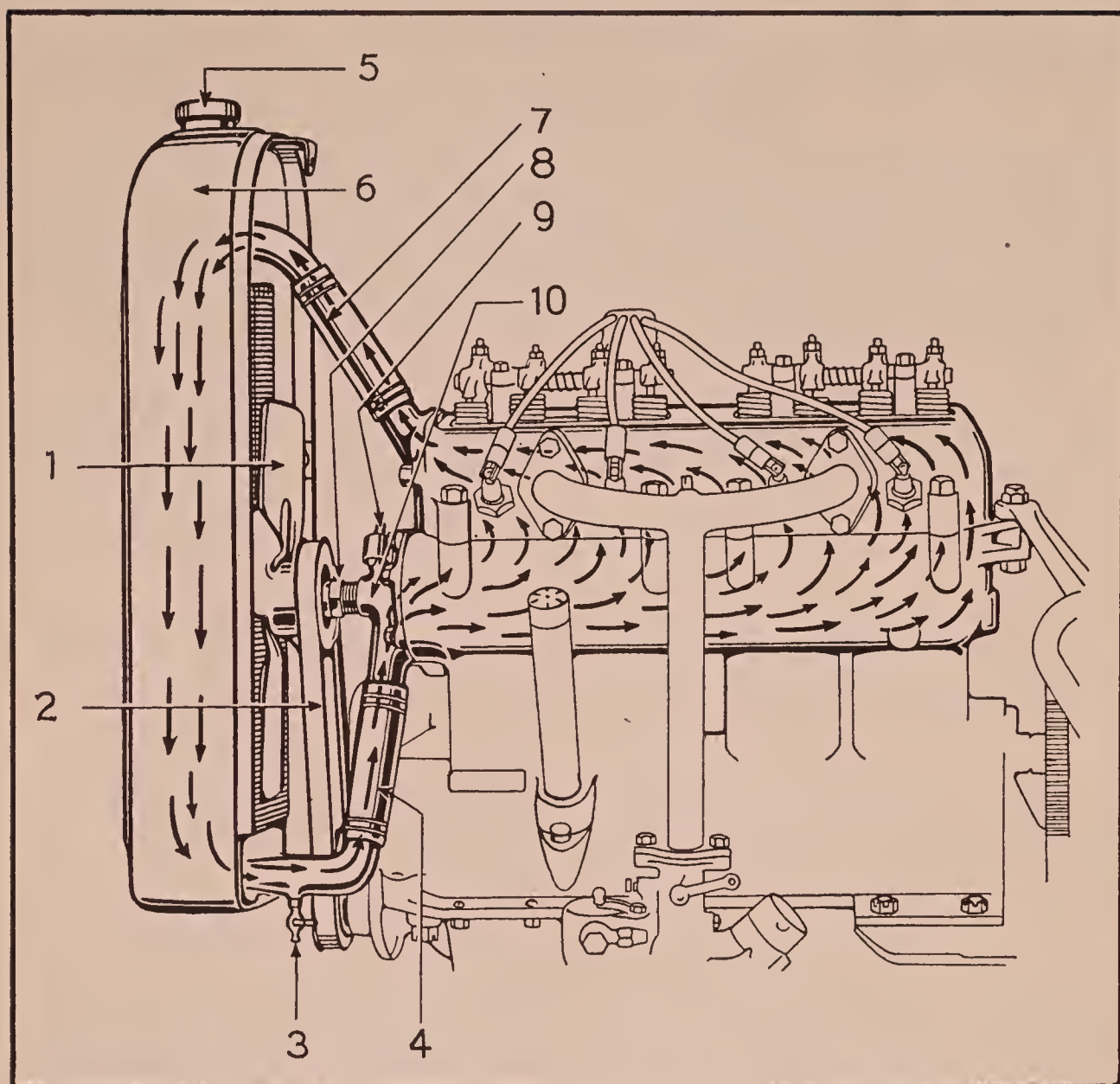


Fig. 37. Cooling System

- | | |
|------------------------------|----------------------------|
| 1 Fan | 6 Radiator |
| 2 Fan belt | 7 Engine water outlet hose |
| 3 Drain cock | 8 Water pump gland |
| 4 Radiator water outlet hose | 9 Lubricator |
| 5 Radiator filler cap | 10 Water pump |

Non-Freezing Solution—A suitable and safe non-freezing compound should meet the following conditions:

1. It should contain no powerful chemicals that will have a harmful effect on any part of the cooling system, either on iron, brass, lead, or rubber;
2. It should be easily dissolved in, or combined with, water;
3. It should be relatively inexpensive;
4. Its boiling point should be equal to or above that of water to prevent waste through evaporation;
5. It should not deposit foreign matter in the cooling system.

Alcohol, denatured or otherwise, makes about the best non-freezing solu-

tion, as it sets up no destructive action on either metal or rubber, nor does it cause any deposit to form. It has, however, the disadvantage of evaporating more rapidly than water, so that when replenishing the water supply alcohol should also be added. A combination of alcohol and glycerine is good (50% of each); glycerine alone has a rather destructive action on rubber, but the addition of alcohol seems to prevent this action, whilst the glycerine prevents the alcohol from evaporating too rapidly. Calcium chloride, also, is good, but it causes an undesirable electrolytic action where two metals of a different kind are joined, such as brass and solder in the radiator; use only absolutely pure calcium chloride.

In the following table will be found the proportions of the various mixtures and their freezing points:

FREEZING POINTS OF ALCOHOL AND WATER SOLUTIONS

Per cent. by Volume of Alcohol	Specific Gravity of Solution	Freezing Point
10	0.988	24° F. (-4.5° C.)
20	0.975	14° F. (-10° C.)
30	0.964	-1° F. (-19.5° C.)
40	0.954	-20° F. (-29° C.)
50	0.933	-32° F. (-35.5° C.)
60	0.913	-45° F. (-42° C.)
70	0.897	-67° F. (-55° C.)

FREEZING POINTS OF ALCOHOL, GLYCERINE, AND WATER SOLUTIONS

Alcohol and Glycerine* Per Cent.	Water Per Cent.	Freezing Point
15	85	20° F. (-6.5° C.)
25	75	8° F. (-13° C.)
30	70	-5° F. (-20.5° C.)
35	65	-18° F. (-28° C.)
40	60	-24° F. (-31° C.)
45	55	-30° F. (-34.5° C.)
50	50	-33° F. (-36° C.)

FREEZING POINTS OF CALCIUM CHLORIDE SOLUTIONS

Per cent. by Volume of Calcium Chloride	Specific Gravity of Solution	Freezing Point
10	1.085	22° F. (-5.5° C.)
15	1.119	13° F. (-10.5° C.)
20	1.131	0° F. (-18° C.)
22	1.200	-9° F. (-23° C.)
24	1.219	-18° F. (-28° C.)
26	1.242	-28° F. (-33° C.)
28	1.268	-42° F. (-41° C.)

* 50% of each

It will be noted that the specific gravity in two of the above tables can be used for checking the strength of the solution. A battery hydrometer can be used to take specific gravity readings of calcium chloride solutions, but in testing an alcohol and water solution it will be necessary to procure a hydrometer for measuring the specific gravity of liquids **lighter** than water.

If wood alcohol be used instead of denatured or grain alcohol, slightly lower temperatures can be reached with the same proportions of alcohol and water.

With the exception of alcohol, denatured or otherwise, it is best to clean the cooling system after using non-freezing solutions, as some of the materials used to prevent freezing frequently form a deposit or coating on the water-jacket and radiator surfaces. They therefore prevent in a greater or less degree the radiation of heat.

Glycerine sometimes leaves a varnish-like coating. Some of the so-called radiator cements form a coating, also, detrimental to proper cooling. These coatings should be removed from time to time; if the radiator leaks, it should be soldered at the first opportunity. The continued use of alkaline water causes heavy encrustations or scale to be deposited throughout the cooling system.

If the coating or deposit is loose (it may be visible through the radiator filler spout), it can be removed merely by flushing with a hose and running water; see **Flush the Cooling System**.

If flushing with water is not successful, try the washing soda or lye solution given in **Removal of Scale**, using it in the manner described therein.

Should failure still result, try a dilute solution of hydrochloric (muriatic) acid and water. In using this solution, remember that it is quite strong and may corrode the metals of the cooling system. It should remain in the system only long enough to remove the scale or coating and should then be completely flushed out with a hose and running water; after running the car a few hours, it is advisable to flush the cooling system again.

As a last resort in removing scale formed by the use of alkaline water, try a steam-boiler scale-remover.

Pieces of foreign matter, such as fragments from the hose connections, can sometimes be dislodged from the radiator tubes by removing the radiator from the car, turning it upside down, and flushing with a hose and running water through the radiator water outlet (now at the top).

Most of the above solutions have a corrosive affect on painted and varnished surfaces, as well as on the hose connections.

Fan Belt—If the belt is greasy, wash it with a clean cloth or a stiff bristle brush and gasoline; if it is worn or stretched to such an extent that it does not drive the fan, replace it—particularly if during hot weather.

Cover the Radiator—In cold weather, the engine may operate at too low a temperature for efficient running. This condition can be corrected by the use of a radiator cover of oil- or rubberized cloth to shut off as much of the radiator to the entrance of air as circumstances may require. The cover should be attached to the lower part of the radiator and as much more likewise covered as may be necessary.

A Frozen Engine—Special care must be exercised lest the cooling system freeze, for in this case it is very likely the radiator or the cylinders would be injured or the water pump damaged. In any event, expensive repairs would be necessary.

If the cooling system should freeze, have the car removed (do not run the engine lest the water pump be damaged) to a warm place and let it thaw out; pouring hot water on the radiator will hasten this action. After the cooling system has thawed, examine it carefully for leaks before again operating the engine.

An Overheated Engine—If the engine is very hot as a result of insufficient water in the cooling system, do not pour cold water into the radiator if the latter is wholly or partly empty. **It is absolutely necessary to permit the engine to cool before adding cold water, in order to avoid cracking the cylinders or water jacket.**

Hose Connections—Pieces of rubber hose connect the cylinders and the water pump with the radiator. Care should be taken lest these pieces of hose become bent or kinked, thus obstructing the flow of water; they should also be examined from time to time because rubber hose deteriorates and small particles loosen from the insides and may clog the cooling system. It is best, if a hose is noticeably rotted, to replace it at once.

When slipping the hose connections into place, do not apply oil or grease to them to facilitate the operation, as this will cause the rubber to rot; use soap and water. Never use shellac on these connections, as it will be very difficult to remove them.

Water Pump Gland—To prevent leakage of water, the water pump shaft is packed with a gland (8. fig. 37) containing a specially prepared wick packing which prevents leakage.

Periodically examine this gland for leakage; tighten it if any is noted. Do not overtighten the gland, as this will cause rapid wear of the packing and shaft; merely pull it up snug. A deeply cut shaft will cause leakage and should be replaced, as it will not hold the packing.

It is, of course, most desirable that standard Chevrolet packing be used, but should it be unavailable, ordinary candle wicking, well soaked in grease and graphite, will serve; it may be possible, also, to secure a specially prepared wick pump packing.

Unscrew the gland to extract the old packing. Wind the fresh packing

around the shaft **in the direction the latter rotates** and force it into the gland, which should then be tightened.

It is good practice occasionally to remove the water pump gland—say, every 1,000 miles (2,000 km), apply a small quantity of soft cup grease, and replace it.

Dirty Radiator—The radiator tubes, particularly those at the bottom, often become clogged with mud and grease. This, of course, prevents the passage of air through them and hence decreases the cooling area of the radiator; they should be cleaned out from time to time. Use a small stick, gently pushing it through each tube, and wash with water. It may be necessary to use a stiff bristle brush and gasoline or kerosene.

Causes of Overheating—An overheated engine may be caused by one or more of the following:

Pump impeller loose on water pump shaft; slipping fan belt; insufficient water, caused by leaks or an unfilled radiator; rich mixture; improperly adjusted carburetor or carburetor choke; late spark; late valve timing; too large valve lifter clearance; carbon accumulations; insufficient or diluted oil; high compression; dragging brakes; tight bearings between engine and rear wheels; soft tyres; slipping clutch; unskilled driving; continued use of low or second speed, etc.

Frequent draining and flushing of the cooling system will increase its efficiency and therefore add to the life of the engine.

CHAPTER XII

LUBRICATION

Operation of the Lubrication System—Oil is poured into the engine through the oil filler tube (7, fig. 38) to a fixed level or height in the oil pan, as indicated by the oil level gauge. It is then drawn from the oil pan through the oil suction pipe to the oil pump; before entering the oil suction pipe, the oil passes through a screen in the oil pan, where any foreign matter it may contain is removed.

The oil is then forced by the oil pump through the oil distributor pipe to the crankcase, where it is distributed to the four connecting rod oil troughs located directly under the connecting rods; a part of this oil is piped directly to the crankshaft center bearing, thus ensuring adequate lubrication of this important part.

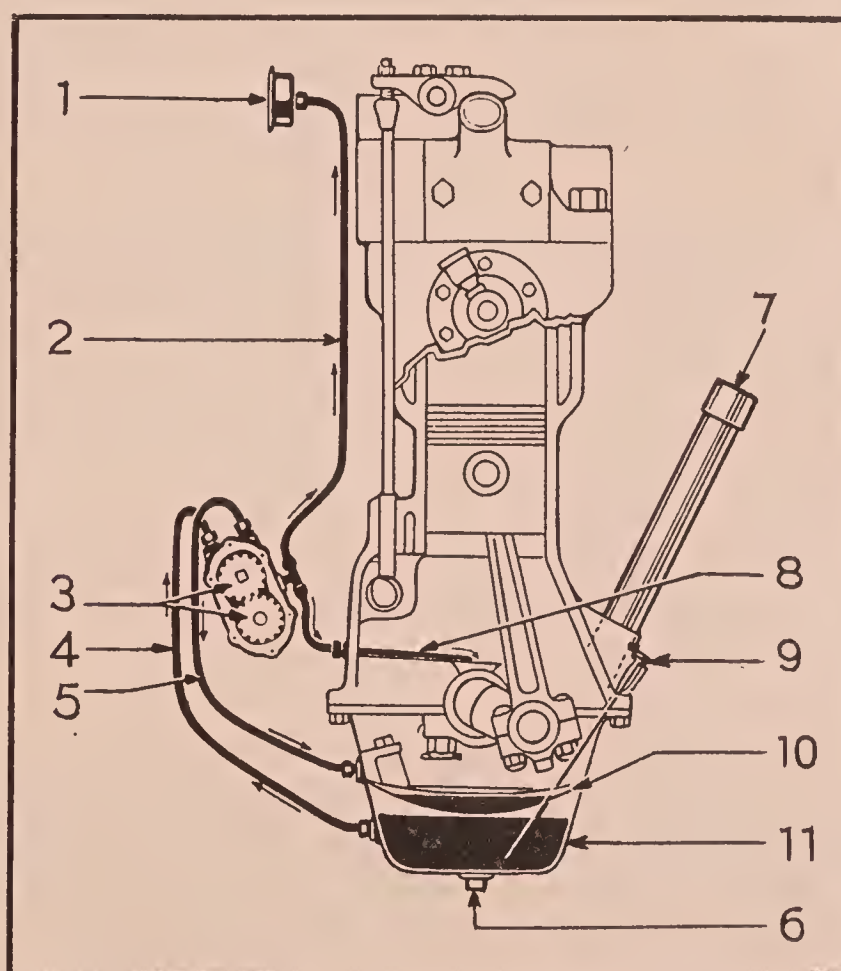


Fig. 38. Lubrication System

- | | |
|---------------------------|--------------------------------|
| 1 Oil pressure gauge | 7 Oil filler tube |
| 2 Oil pressure gauge pipe | 8 Center main bearing oil pipe |
| 3 Oil pump gears | 9 Oil level gauge |
| 4 Oil suction pipe | 10 Connecting rod oil trough |
| 5 Oil distributor pipe | |
| 6 Oil pan drain plug | 11 Oil pan |

The oil is maintained at a constant height in each of the troughs and the connecting rods dip more or less forcibly, depending on the speed at which

they are moving, into this oil, splashing it throughout the crankcase; the quantity of oil thus circulated is therefore proportionate to the engine speed.

In being splashed about in this manner, some of the oil is thrown onto the cylinder walls, where it lubricates these parts and the pistons, and also onto the piston pins and their bearings. In the same fashion, oil is thrown onto the camshaft, ensuring adequate lubrication of the camshaft bearings, the cams, valve lifters, and valve lifter guides. The crankshaft front and rear bearings are also lubricated in this manner, and a small quantity of oil finds its way through a hole drilled in the crankshaft rear journal to the clutch spring tension rod bearing in the fly-wheel.

With the exception of the cylinders and pistons, all the parts receive an oversupply of oil; a part of this oversupply to the crankshaft front bearing passes into the timing gear case, thus lubricating the timing gears and the generator driving gear. A very small part of the oil works its way past the pistons into the combustion chambers, where it is consumed with the fuel. The excess oil drains into the oil pan and thence through the oil screen and the oil suction pipe back to the oil pump, whence it is again circulated throughout the system.

It can be readily seen that this form of construction, which is known as the splash type with circulating pump (often referred to as the constant level splash system), is simple and reliable to a degree and highly economical with respect to oil consumption; the fact that it is more widely used than any other system may be taken as sound evidence of its worth. It is a system that requires practically no attention other than replenishment of the oil consumed and changing of the oil supply at certain intervals.

Beyond ordinary wear and tear and excepting accidents, the engine lubrication system can be entirely relied upon. There are, however, certain other factors of equal importance to that of an efficient lubrication system that must have consideration.

Why it is Necessary to Change the Oil—Any metal surface moving in contact with another metal surface, regardless of how well it may be lubricated, wears out. Minute fragments of metal are torn or broken from it and accumulate in the oil, which thus soon becomes filled with abrasive particles. In the case of a motor car engine, road dust and other particles of foreign matter in the air find their way into the cylinders and crankcase, and eventually into the oil. Carbon, also, which forms on the undersides of the pistons, collects in the oil.

Crankcase Dilution—A poorly carbureted mixture, whether because of injudicious use of the carburetor choke or incorrect adjustment of the carburetor, contains a greater or less quantity of raw fuel which is not wholly consumed. This unburned fuel, on coming into contact with the oil film on the cylinder walls, is carried into the oil pan, where it dilutes and hence contaminates the oil.

This condition is especially marked during a series of short runs when the engine is frequently started and stopped—particularly in cold weather. In addition to this, unburned fuel that remains in the cylinders after the engine has been stopped flows into the crankcase, a condition likewise particularly true in cold weather and one that is also aggravated by frequent starting and stopping of the engine. The use of low-grade, heavy fuels accentuates this condition, because the heavier parts of such fuels are not entirely vaporized in the carburetion process preparatory to their admission into the cylinders, but remain in a liquid state and drain into the crankcase.

Lubricating oil thus diluted and contaminated has little or no lubricating value and soon becomes a source of very rapid wear to the various bearing-surfaces of the engine. The preventive, of course, among other things, is careful manipulation of the carburetor choke and correct adjustment of the carburetor, but frequent changing of the oil is essential, also, for in addition to providing fresh, undiluted oil at frequent intervals, this practice removes foreign matter that accumulates in the crankcase: dust, particles of carbon and metal, water, etc.

How to Avoid Crankcase Dilution—Strict attention to the items enumerated below will prevent crankcase dilution:

1. Avoid excessive use of the carburetor choke. After starting the engine, wait until it is well heated before starting the car.
2. During cold weather, use a radiator cover to permit the engine to heat more rapidly and also to maintain it at a higher operating temperature. Crankcase dilution is much more prevalent with a cold engine than with a hot one; heat makes for better carburetion and improves combustion of the fuel.
3. Do not idle the engine—run it throttled down—or drive excessively slowly for long periods of time. This practice causes an objectionable condition to be set up within the engine and tends to increase dilution.
4. Keep the engine in good mechanical condition. Scored or worn cylinders, pistons, or piston rings, defective ignition apparatus, valves in need of grinding—all these promote dilution. (See below for further remarks on this subject.)
5. Drain the oil pan regularly; see ROUTINE CARE, and below.
6. Do not flush the oil pan and lubrication system with kerosene, as it is impossible to drain all the pockets without removing the oil pan; the kerosene that is caught in these pockets remains and dilutes the fresh oil. **Use a flushing oil or clean engine oil.**

Drain the oil pan whilst the engine is hot and the oil thoroughly agitated. Slightly increase the speed of the engine and let it run in this manner for a minute or so before stopping it and removing the oil pan drain plug; this practice will help carry off the sediment.

Worn Parts and Heavier Oils—The importance of keeping an engine in good mechanical condition can not be overemphasized if the best results with respect to correct lubrication, moderate fuel consumption, and ample

speed and power are to be had; worn parts, such as have been mentioned in item 4, above, make for excessive dilution.

Even an engine in the pink of condition may be subject to a high degree of crankcase dilution when idling for long periods of time, yet this same engine would show no dilution whatever when driven at high speeds through the countryside. Such an engine will emit dense clouds of oil smoke—bluish-grey in color—when it is driven off after idling for a considerable period, and car owners are often prone to believe that a heavier oil than that recommended by the car manufacturer will be better for his engine.

Many drivers believe that wear can be compensated by the use of a heavier oil. Whether it is oil pumping—accumulation of oil in the cylinders whilst the engine is idling—or worn parts that are to be corrected, the use of a heavier oil than that recommended by the car manufacturer inevitably results in more numerous and more dangerous ills.

Heavier oils can not replace metal that has worn out in service. They can not restore broken or worn pistons and rings. Nor can they make round cylinders that have become oval. The use of heavier-bodied oils is always followed by such things as fouled spark plugs, sticking valves, rapid carbon formation and its attendant knocking, defective operation of the lubrication system in general, lessened power and speed, etc.

Carbon Formation and Oil Pumping—As a general thing, most people blame the oil they are using for rapid carbon formation, when it is their carburetor that is at fault. And then, again, it may be themselves that should be blamed, because of their poor driving—running with a retarded spark, with the choke needlessly pulled out, idling the engine unnecessarily, and the like.

It is true that oil is to a certain degree responsible for a part of the carbon formed in engines, but usually this is because of overoiling. If too much oil is poured into the oil pan, too much will reach the cylinders. Or if the engine is idled excessively, oil pumping results—too much oil enters the cylinders.

Both these conditions—rapid carbon formation and oil pumping—can be prevented in a very large measure as follows:

1. Use the oil recommended in chapter III, part one.
2. Fill the oil pan to the right level daily, or whenever the engine is used, if not daily. Add only sufficient oil to bring the level to FULL on the oil level gauge.
3. Keep the engine in good mechanical condition, and do not use a heavier-bodied oil to compensate wear.
4. Do not use a heavier-bodied oil to increase the oil pressure. If the oil pressure is not what it should be, do not attempt to adjust the oil pump nor substitute a heavier oil, but determine the cause of the condition at once.
6. Make certain the carburetor is correctly adjusted and that the carburetor choke is properly used. Unless the right mixture enters the

- cylinders, clean combustion can not take place; the oil in the cylinders will not be completely burned and a residuum of carbon will be left.
7. Keep the ignition apparatus in good condition. Defective ignition distributor breaker points, fouled spark plugs, and loose connections cause misfiring which, in turn, promotes oil pumping and carbon formation.
 8. Unless the mixture in the cylinders is highly compressed, it can not burn properly. Worn pistons and rings, burned valves, a loose cylinder head, or loose spark plugs cause poor compression and should be attended to.

Oil Sludge—Oil sludge—a slimy, pasty substance that forms in the oil—must be guarded against even more carefully than oil dilution and carbon formation; its presence in the oil will cause more damage to the engine parts, and more quickly, than even a high degree of oil dilution.

The formation of sludge in the engine oil is a result of a combination of causes and is really an emulsion—a milky, fatty liquid—formed by water in the presence of road dirt, carbon, and minute metal fragments such as are always found in the oil pan.

In general, little is understood by the average car owner of the accumulation of water in the oil pan, but the cause is simple: A cold crankcase—which is the condition obtaining in an engine when first started and until it is well heated—acts as a condenser of the water vapor in the exhaust gases that leak downward past the pistons in even the best of engines. Because of this leakage, oil sludge is more likely to form in a worn engine than one in good condition. When the crankcase becomes thoroughly warm, as when the engine has been run for ten or fifteen minutes, the greater part of these exhaust gases no longer condense, but pass through the crankcase breather to the outer air.

How to Avoid Oil Sludging—The formation of sludge in the oil can be prevented, or at least reduced, as follows:

1. Whilst the engine is warm, drain a cupful of oil from the oil pan. If it contains a quantity of water, repeat the operation every three or four days, until all the water has been removed.
2. In cold weather, use a radiator cover. Keeping the operating temperature at a high point reduces the formation of sludge and the tendency to dilution.
Excessive quantities of water accumulate in the oil in cold weather. Such water collects in pockets and freezes, thus preventing the circulation of oil.
3. Clean the oil screen regularly every 1,000 miles (2,000 km.), as directed in ROUTINE CARE.
4. The quality of the fuel used has a direct effect on the accumulation of water in the oil; a high test gasoline is best. Endeavor to obtain a fuel of the highest quality and use it consistently; avoid the selection of fuels at random. See page 25.

5. If sludging should occur, make certain every trace of it is removed from the oil pan and the lubrication system in general before refilling with fresh oil. Do not rely on mere flushing, but remove the oil pan and thoroughly clean it and as much of the interior of the engine as can be reached.

Unless the lubrication system is perfectly cleaned after sludge has once formed, it will appear again with startling rapidity and the complaint will become chronic.

How Frequently Should the Oil Be Changed?—This figure can be placed at 500 miles (1,000 km.) and will meet most driving conditions. The only possible exception may be in very cold climates, particularly when a large number of short runs is made with frequent starting and stopping of the engine; under such circumstances it should be placed at 350 to 400 miles (700 to 800 km.) depending on local conditions. In any case, it is highly inadvisable to exceed 500 miles.

The best way to handle the matter is to fill the oil pan to the proper level and run on this oil until 500 miles (1,000 km.) have been covered, replenishing the supply during this period only if the oil level falls below FULL on the oil gauge rod, when sufficient oil should be added to raise the oil level to this mark. **Test the oil level daily, or each time the engine is used, if not daily.**

Do not overfill the oil pan, as this will only cause smoking at the exhaust, spark plug fouling, rapid carbon formation, excessive oil consumption, and kindred evils.

After 500 Miles, Drain the Oil Pan—

1. Run the engine until the oil is well heated and thoroughly agitated;
2. Remove the drain plug, replacing it when the oil pan is empty;
3. Pour one quart (1 litre) of clean, slightly heated engine oil* into the oil pan, run the engine for five minutes, stop the engine, drain, and replace the drain plug.
4. Fill the oil pan with clean engine oil of the recommended grade.

Under no circumstances flush the oil pan with gasoline or kerosene; use only clean engine oil.*

Always remember, before draining or filling the lubrication system, to remove all dirt adjacent to or on the drain plug, level gauge, and the oil filler tube and its cap, to prevent its entrance into the lubrication system.

The engine has an oil capacity of 4 quarts (3.3 imp. qts., 3.78 litres).

Removing and Cleaning the Oil Pan—

1. Run the engine until the oil is well heated and thoroughly agitated;
2. Drain the oil;
3. Remove the cap screws holding the oil pan to the crankcase;

*Flushing oil, especially made for this purpose, may be used instead of engine oil

4. Thoroughly wash the interior of the oil pan and the connecting rod oil troughs with gasoline or kerosene, using a **clean cloth free from lint or loose threads** and a stiff bristle brush;
5. Wash the oil screen;
6. Wash the exterior of the oil pan;
7. Dry and then fill the connecting rod oil troughs with clean engine oil;
8. Replace the oil pan;
9. Fill the oil pan to the correct level with fresh, clean engine oil.

In carrying out the above operations, be careful not to injure the gasket between the oil pan and the crankcase, or it will have to be replaced to prevent oil leakage. And always take advantage of the opportunity thus presented to make a thorough examination of the parts in the crankcase, such as the connecting rod and crankshaft bearings, the piston pin bearings, etc.

The Oil Pressure Gauge—When the engine is running, the oil pressure gauge registers the amount of pressure on the oil then being circulated; it therefore denotes the degree of force with which oil is fed to the various points. **IT DOES NOT, HOWEVER, INDICATE THE AMOUNT OF OIL IN THE OIL PAN.**

This instrument is really the most important component of the lubricating system, for the driver relies entirely upon it for his information as to the system's proper functioning. So long as the gauge shows pressure is being maintained on the oil, the driver knows the latter is circulating properly; but should the pressure gauge fail to register, the engine should be immediately stopped and the cause of the fault determined and remedied.

Oil Pressure—The normal oil pressure is 4 to 8 pounds (0.3 to 0.6 kg.) Any material increase in pressure beyond these figures, say, to 10 pounds (0.7 kg.), indicates an obstruction in the center main bearing oil feed pipe. A smaller pressure than 2 pounds (0.14 kg.) is an indication that the lubrication system is not functioning properly and the engine should be immediately stopped and an investigation made to determine its cause.

Low oil pressure or none at all generally results from air leaks in the oil suction pipe connections and can, in most instances, be corrected merely by tightening the unions at the lower and upper ends of this pipe. Sometimes, however, the oil suction pipe may be cracked or even broken, or possibly it may have been so acutely bent that oil will not flow through it; in either of these cases the pipe must be removed and repaired or replaced, as conditions may dictate. Still another cause may be dirt, carbon, sludge, or other foreign matter that has accumulated upon or has passed through the oil screen into the oil suction pipe, lodging there, or perhaps found its way into the other oil pipes, obstructing them. Such a contingency necessitates removal of the oil screen and pipes and their cleaning by blowing out with air or otherwise.

Finally, if all other measures fail, the oil pump should be examined. Disconnect the oil pipes leading to it and remove it from the engine. In re-

moving the oil pump cover, be careful not to damage the paper gasket between it and the oil pump body; if necessary, replace the gasket with another of paper of the **same thickness**. If the oil pump gears are so badly worn that their teeth do not fit tightly against one another or against the sides of the pump body, replace them.

Oil Pump Gland—It sometimes happens that a slight leak develops at the point where the oil pump shaft enters the oil pump body. In this event, the oil pump should be removed and the oil pump gland (a brass, nut-shaped piece), sufficiently tightened with a wrench to stop the leak. Do not tighten the gland too much lest the shaft be damaged.

If tightening the gland has no effect on the leak, the old packing should be removed and the gland repacked with ordinary candle wicking or soft, well greased cord.

Little or No Oil Consumption—It sometimes happens that an engine uses very little oil, or even none at all. In certain extreme cases it has been found that more oil—or what looks like oil—is in the oil pan at the end of 500 miles (1,000 km.) than was put in it at the beginning of that period.

This condition is generally due to dilution of the oil by unburned fuel and immediate steps should be taken to correct it, such as proper manipulation of the carburetor choke, correct adjustment of the carburetor, covering the radiator during cold weather, or all three.

If little or no oil is consumed by the engine, drain a sample from the oil pan and examine it. If it is watery in consistency—thin, with but little body, or if it smells strongly of fuel, a high degree of dilution is present; the oil should immediately be drained from the oil pan and replaced with fresh oil of the right grade.

Chassis Lubrication—Each important point (on the chassis) to be lubricated is equipped with fittings (lubricators) for the pressure grease gun form of lubrication. Before lubricating, wipe the fittings clean, to prevent foreign matter entering the bearings with the grease.

To fill the grease gun, disconnect the flexible hose from the cylinder (see fig. 39); **do not twist the hose**. Unscrew the piston rod, so that the leather cup at its end is drawn up inside the cylinder head; this will facilitate replacing the piston in the cylinder. Fill the cylinder with soft cup grease.

To avoid air bubbles and completely to fill the cylinder, jar or shake the grease by gently tapping the cylinder. Replace the head and screw it down, **tightening by hand only**.

To use the compressor, slip the coupling at the end of its hose over a lubricator, press it in, and turn it to the right, thus locking the coupling and ensuring a tight joint. Give the compressor a few turns, until the old grease is forced out of the opposite side of the bearing being lubricated. If grease does not enter the bearing, it is because the latter is clogged, and it should then be disassembled and cleaned. Relieve the pressure by unscrewing the

compressor handle three or four turns and remove the coupling by pressing in on it and turning it to the left. Wipe the lubricator clean and, before storing the grease gun away, remove the hose by unscrewing the hexagonally-shaped end and clean it.

In forcing grease into the bearings, never use anything but the hand to turn the handle of the grease gun, as more than enough pressure is obtained in this manner to force the dirt and old grease out of the bearings and the fresh grease in. Using a tool to increase the pressure can only result in damage to the gun, the hose, or the lubricators. A pressure of 500 pounds to the square inch (35 kg. to the sq. cm.) is secured merely by the use of the hand. When connecting the flexible hose to a lubricator, be careful not to bend it too acutely lest it be damaged. The hose should never be twisted in removing it from a lubricator or the cylinder; turn it by means of the hexagonally-shaped part.

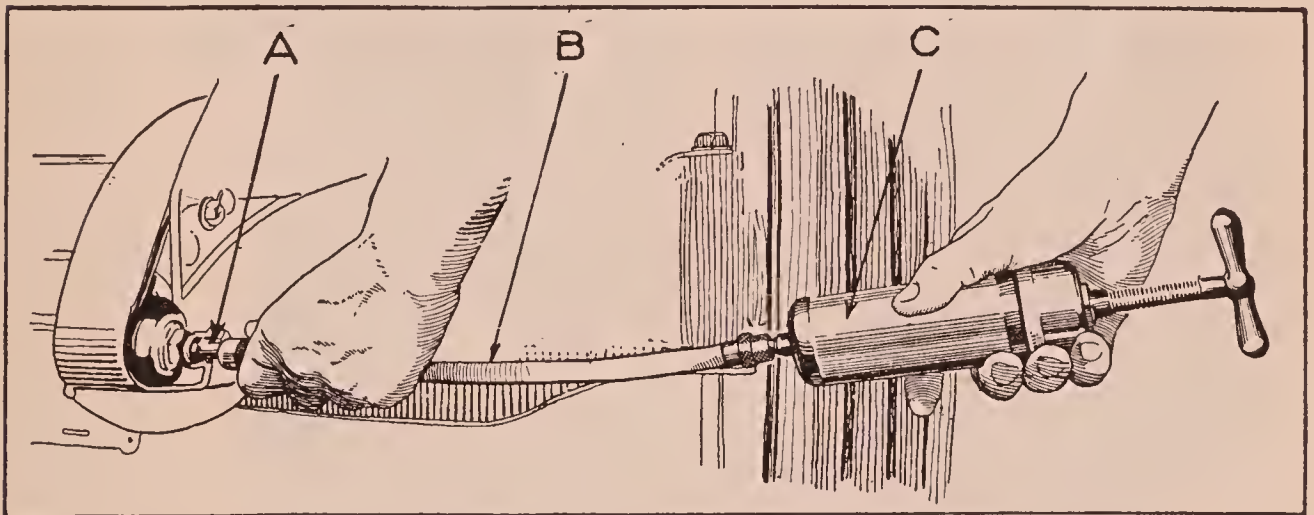


Fig. 39. Attaching Pressure Grease Gun to a Lubricator

A Lubricator B Pressure grease gun flexible hose C Pressure grease gun

The one certain preventive of improper functioning of the engine lubrication system is frequent draining and flushing of the oil pan.

Thorough lubrication of a motor car—and therefore its chances of a long life—can be simply and relatively inexpensively ensured by the use of plenty of lubricants of the recommended grades. Lubricants are cheap, especially when compared to the cost of replacements or repairs of parts worn out before their time by careless lubrication.

Four quarts of oil will carry your engine 500 miles. Four quarts of oil may carry your engine 1,000 miles, also, or 1,500 miles, but in this case they will inevitably carry you further than you expect: to your banker.

Why not let the correct use of the right lubricant eliminate the “friction” from the satisfaction it is possible for you to derive from your car as it does from the bearings of your engine?

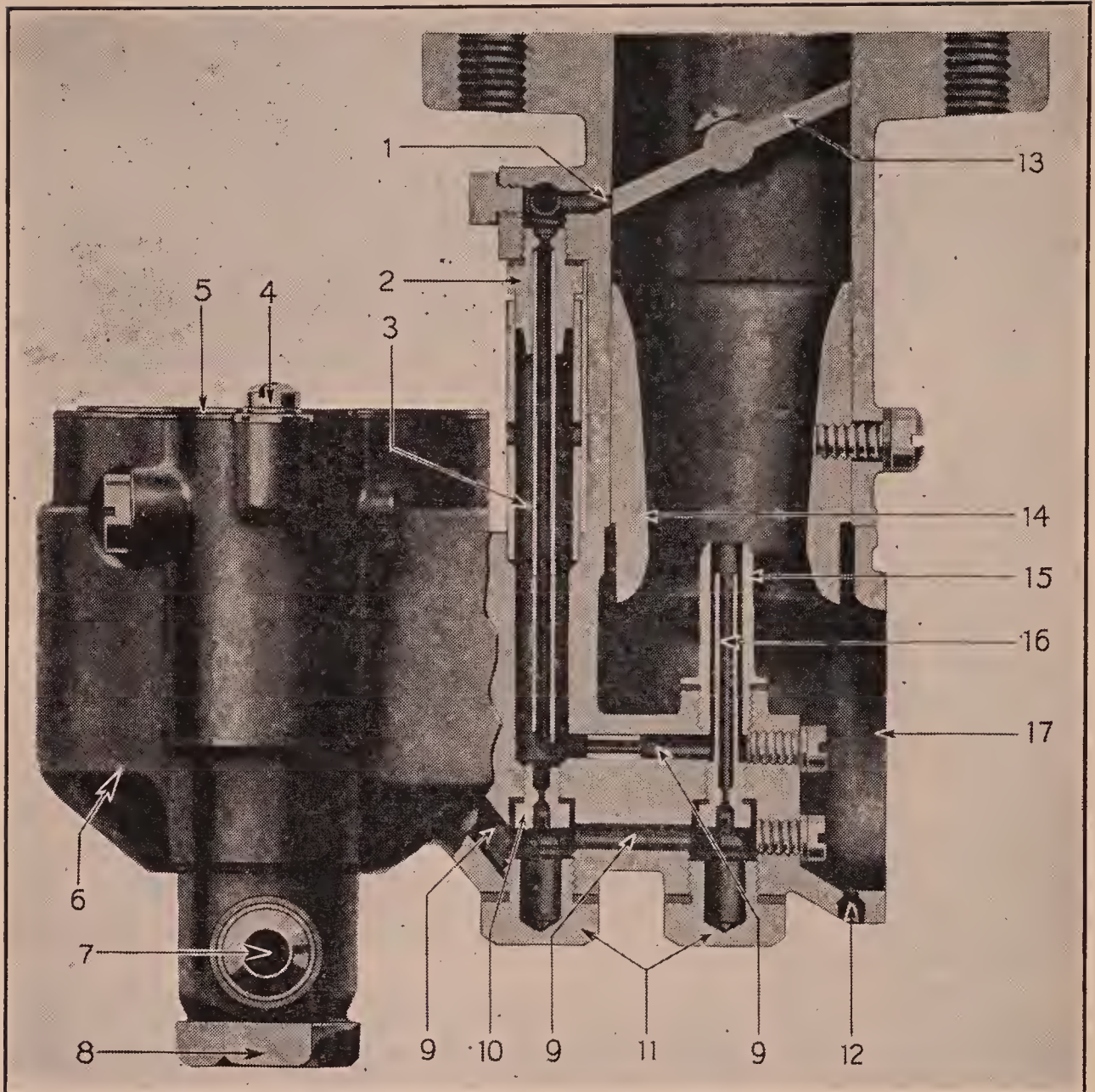


Fig. 40. Sectional Side View of of Carburetor

- | | | | |
|---|---------------------------|----|--------------------------|
| 1 | Priming hole | 9 | Fuel passage |
| 2 | Idling fuel nozzle | 10 | Compensating fuel nozzle |
| 3 | Atmospheric well | 11 | Drain plugs |
| 4 | Float chamber cover screw | 12 | Drain hole |
| 5 | Float chamber cover | 13 | Throttle valve |
| 6 | Float chamber | 14 | Venturi tube |
| 7 | Fuel inlet | 15 | Cap fuel nozzle |
| 8 | Drain (filter) plug | 16 | Main fuel nozzle |
| | | 17 | Air inlet |

CHAPTER XIII

THE CARBURETOR AND FUEL SYSTEM

High Altitudes—Extremely high altitudes, as in a mountainous country, generally necessitate a change in carburetor adjustment to secure satisfactory operation of the engine. Hence, if the mixture shows indications of being continuously rich* it will be necessary to reduce the amount of fuel in it, and it is suggested that the car owner have the carburetor attended to by a competent person, instructing him to reduce the amount of fuel in the mixture, thus making it leaner.

A lean mixture is necessary because in high altitudes less oxygen is present in the air and were the mixture not changed it would be too rich. Such a condition would be wasteful of fuel and, in addition, would overheat the engine, decrease power and speed, and would cause rapid formation of carbon; early deterioration of the engine oil by dilution would follow, also. The remedy is less fuel.

Carbon Formation—A mixture is said to be overrich when it contains too much fuel or, conversely, too little air. When such a mixture is burned, only a portion of the fuel can completely combine with the oxygen in the air and, as a result, large quantities of carbon are formed. Although this carbon is free carbon, that is, in the form of tiny crystals, and a certain part of it is therefore carried out with the exhaust gases, nevertheless considerable quantities accumulate on the heads of the pistons and on the cylinder head.

Such carbon firmly adheres to the metal and during combustion becomes white-hot; hence, when these accumulations become large, they cause pre-ignition—ignition of the charges of fuel and air before they should be ignited, thus producing a heavy thump or pound in the engine. This condition if permitted to continue is damaging in the extreme and should be corrected by cleaning.

Overheating—In addition to diluting the engine oil and promoting the rapid formation of carbon, too rich a mixture causes an engine to overheat. This condition results in expansion of the pistons, which then become too large for the cylinders; the abnormally high temperature of the combustion of an overrich mixture burns the oil film on the cylinder and piston walls; either of these causes excessive friction, which in turn increases the already too high temperature of the engine. The power of the engine is thus greatly reduced and parts rapidly deteriorate.

Vacuum Tank—The function of the vacuum tank is to provide an ample and continuous flow of fuel to the carburetor. This is accomplished by taking advantage of the vacuum set up within the cylinders and inlet manifold when the engine is in operation and using it to maintain a steady flow of fuel from the fuel tank to the vacuum tank and thence to the car-

*A rich mixture is generally manifested by a black smoke and strong odor to the exhaust, sluggish engine action, engine speed fluctuating through more or less regular periods from high to low speeds, apparent misfiring, overheating, and excessive fuel consumption.

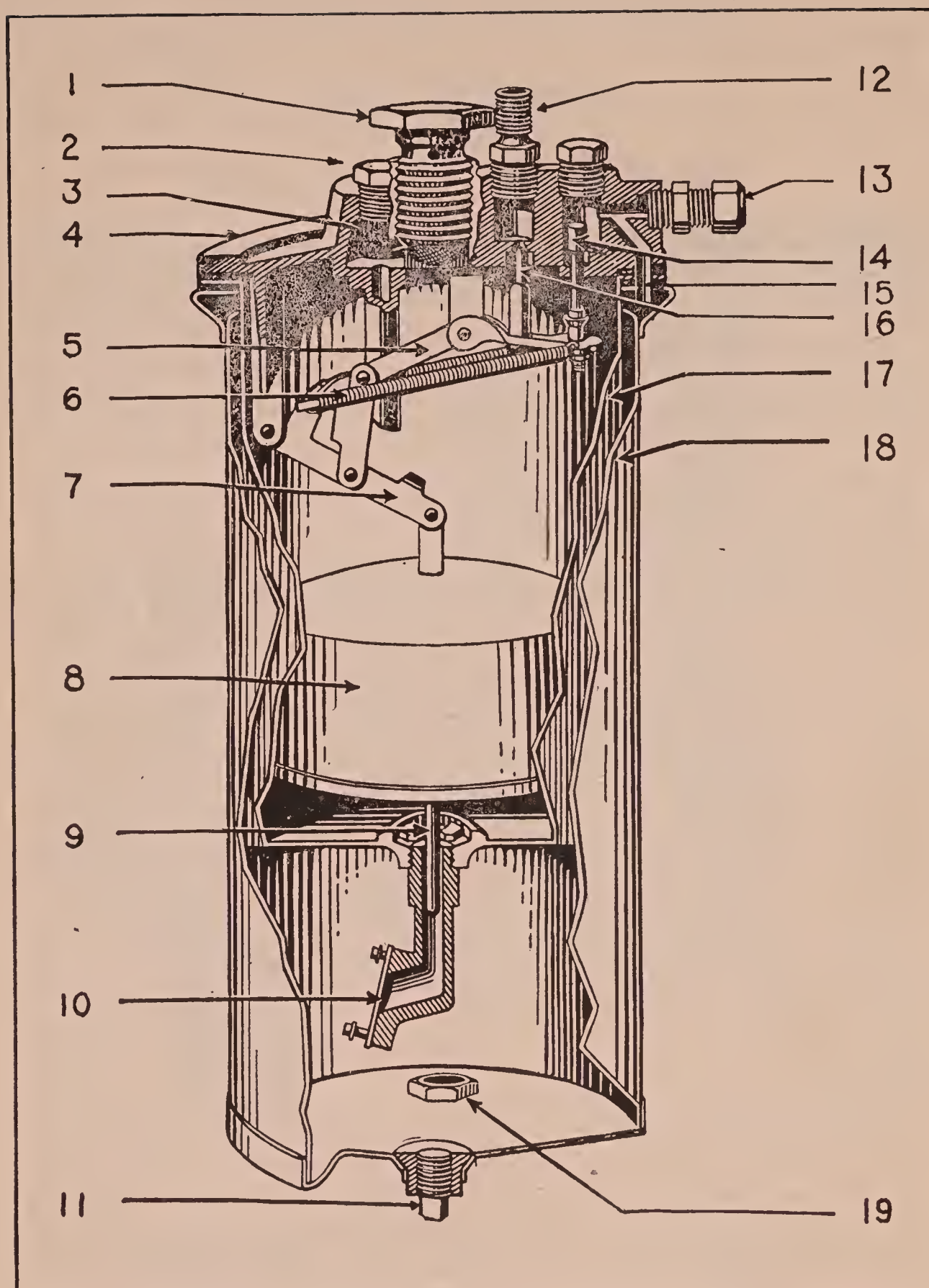


Fig. 41. Stewart Vacuum Tank

- | | |
|------------------------------------|---------------------------|
| 1 Fuel pipe connection | 10 Flapper valve |
| 2 Filler plug | 11 Drain plug |
| 3 Fuel filter screen | 12 Vacuum pipe connection |
| 4 Cover | 13 Air vent connection |
| 5 Valve toggle lever | 14 Air valve |
| 6 Valve toggle lever spring | 15 Air passage |
| 7 Float lever | 16 Vacuum valve |
| 8 Float | 17 Inner chamber |
| 9 Float guide rod | 18 Outer chamber |
| 19 Carburetor fuel pipe connection | |

buretor. Complete control over the flow of fuel is had by means of a series of valves and air vents.

As a general thing, defective action of the vacuum tank is caused by dirt or water in the fuel, mostly as a result of carelessness. Such defective action can be readily prevented by taking whatever steps that may be necessary to exclude foreign matter from the fuel, such as its proper storage, filtering, etc. Leaks, both of fuel and air, can be prevented by periodically tightening the pipe joints and the screws in the vacuum tank cover. Beyond this, little attention is needed to insure proper functioning of the vacuum tank.

Caution: Adjusting the Vacuum Tank—Before proceeding with the repair or adjustment of the vacuum tank, make absolutely certain the trouble is not due to some other cause.

Vent Tube Overflows*—The air vent, 13, permits of an atmospheric condition being maintained in the outer chamber and also serves to prevent fuel overflowing in descending very steep grades. If it should happen at long intervals that a very small quantity of fuel leaks from the vent, no concern need be felt and no adjustment is needed. If, however, the vent tube overflows regularly, it is quite likely the air vent **in the fuel tank cap** is too small or clogged with foreign matter, thus preventing the entrance of air through it. In this case the hole should be enlarged somewhat or cleaned out, as the case may be

Failure of Fuel Feed to Carburetor—In a difficulty of this nature one should remember it may be due to causes other than faults of the vacuum tank such as are enumerated in succeeding paragraphs, where directions for correcting the difficulty will also be found.

In event of defective fuel feed, proceed as follows:

1. **See that the fuel shut-off cock is fully open.**
2. Remove the carburetor float chamber cover to determine if fuel is in the carburetor.
3. See that there is sufficient fuel in the fuel tank, at the same time noting whether the air vent—the small hole—in the fuel tank cap is free from obstructions.
4. Remove the drain plug from the bottom of the vacuum tank. Failure of fuel to flow from the vacuum tank drain indicates obstructions or air leaks in the fuel pipe,¹ vacuum pipe,² fuel tank outlet or suction pipe,³ a jammed vacuum tank valve, sediment in fuel filter,⁴ or a clogged air vent.
5. Remove and clean the carburetor fuel filter.
6. There may be dirt in the carburetor fuel nozzles. Remove and clean them, either by blowing through them or by means of a piece of **fine, soft copper wire.**

*Stewart tank only.

1. Runs from fuel tank to vacuum tank.
2. Runs from inlet manifold to vacuum tank.
3. Runs from interior of fuel tank to connection at rear end of fuel pipe
4. In top of vacuum tank.

7. There may be water in the carburetor. Remove it by opening the carburetor drains (8 and 11, fig. 40); **inspect the drain plugs for leaks after replacing them.**
8. Water may have frozen in the fuel; see page 120 for treatment.

If the above measures fail, remove the top of the vacuum tank and take out the float and other mechanism, leaving only the outer shell in place. If, after filling this shell with fuel, the engine still fails to run properly, the fault is clearly not that of the vacuum system.

Should the fault be that of the vacuum tank, as indicated by the engine running properly when the outer shell is filled with fuel, and repairs can not then be made, plug the vacuum pipe to prevent the entrance of air into the inlet manifold and fill the vacuum tank with fuel drained from the fuel tank, replenishing the supply from time to time by hand.

Removing Vacuum Tank Top—After removing the screws in the cover of the vacuum tank, insert a knife blade between the latter and the cover to separate them without damaging the gasket, which is shellacked in place to ensure an airtight joint; if the gasket is damaged in removal, it must be replaced with a new one to prevent leakage.

Leaky Vacuum Tank Float—The vacuum tank float must be air tight, for if a leak should develop the float would fill with fuel, thus making it too heavy to function properly. Such a condition would prevent the flow of fuel into the upper chamber being shut off when it should be. In this event, the fuel, after filling the upper chamber, would flow into the inlet manifold and thence into the cylinders, probably stopping the engine.

To repair the float, remove it and immerse it in hot water to locate the leak; bubbles will be noticed at the leak and this spot should be marked. Two very small holes should then be punched in the float, one at the top and the other at the bottom, to permit the fuel to flow out of the float. When the float is emptied of fuel and thoroughly dry, carefully solder the two holes and the leak and test the float by again immersing it in hot water.

In soldering the float, be careful to use no more solder than is actually required to make a substantial repair, because the addition of superfluous solder will make the float too heavy to act properly.

Caution—In removing and replacing the float, be careful not to bend the float guide rod,* for if this rod is bent the float will not function properly; largely the same effect as a leaky float will result. If the rod is not perfectly smooth, improper action will follow; smooth it with fine emery cloth if necessary.

Flapper Valve—Should foreign matter lodge on the flapper valve seat, the valve will not close tightly and will be rendered inoperative. To determine if the flapper valve is out of order, plug the air vent and disconnect the carburetor feed pipe. Crank the engine by means of the starter motor and apply a finger to the carburetor feed pipe connection (in the bottom of

* G. G. tank, vacuum valve, also

the vacuum tank). If a continuous suction is felt, the flapper valve is not properly seated.

In this case,* pour a half-pint (0.25 litre) or so of fuel into the tank to wash away the obstruction on the flapper valve seat. Should this treatment fail, remove the inner chamber and wipe the valve seat clean.

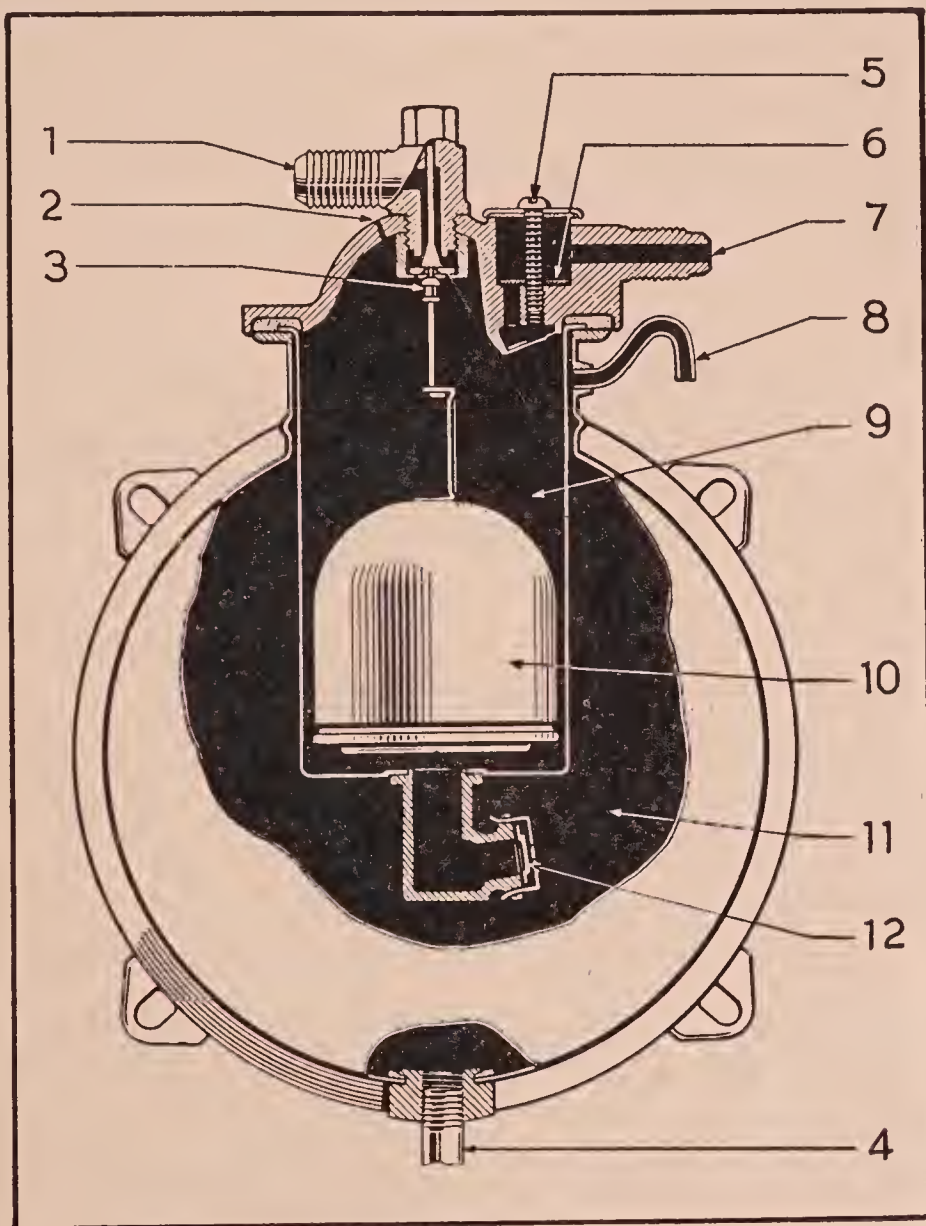


Fig. 42. G. G. Vacuum Tank

- | | |
|-----------------------------------|-----------------------------|
| 1 Vacuum pipe connection | 6 Fuel filter screen |
| 2 Air vent to inner chamber | 7 Fuel pipe connection |
| 3 Vacuum valve | 8 Air vent to outer chamber |
| 4 Carburetor fuel pipe connection | 9 Inner chamber |
| 5 Fuel filter screw | 10 Float |
| | 11 Outer chamber |
| | 12 Flapper valve |

Air Leaks—Should the connections at either end of the vacuum pipe loosen or should this pipe be cracked, air will be drawn into the inlet manifold, which will not only cause the engine to run badly but also will

* G. G. tank, remove the fuel filter; Stewart tank, the filler plug.

prevent proper action of the vacuum tank; very likely a hissing or whistling sound will be heard. Tighten the connections; if the pipe is cracked, repair or replace it.

This is also true of the fuel and fuel tank suction pipes, which should be treated in the same manner.

Choked Pipes, Fuel Filters, Etc.—Obstructions in the vacuum pipe will prevent the vacuum tank filling with fuel. Remove the pipe and clean it.

To determine if the fuel pipe is choked, disconnect it (with the engine running) from the fuel tank and immediately apply a finger to the opening in it. If no suction is felt, the pipe is clogged, and the obstruction should be removed by blowing through the pipe. Use compressed air if it is available, or force a suitable piece of steel or bronze spring-wire through the pipe.

The vacuum pipe can be tested and cleaned in the same manner.

Accumulation of sediment will prevent proper action of the air valve, 14 (fig. 41), and the air vent, 13, also; the vacuum tank would then fill with fuel, but there would be no flow to the carburetor. Remove the air valve, 14, and wash it and the air vent, 13, with fuel.

This is likewise true of the G. G. vacuum tank. If the air vents (2 and 8, fig. 42) should become clogged, there would be no flow of fuel to the carburetor; the remedy is obvious—removal of the obstruction.

The accumulation of foreign matter in the vacuum tank filter-screen will prevent the flow of fuel into the inner chamber, although all else be in order. Remove the filter-screen and carefully clean and replace it.

Remove the filter screen from the carburetor (11, fig. 43) and treat it in the same manner. **Be careful not to injure this delicate part.**

Accumulations of sediment in the bottom of the vacuum tank will clog the fuel outlet in its bottom, thus shutting off the flow of fuel to the carburetor. The drain plug or pipe connection should then be removed from the bottom of the vacuum tank and the tank itself thoroughly flushed out. In these circumstances, it is advisable to disconnect and clean the feed pipe between the vacuum tank and the carburetor; or it may be necessary to remove the inner chamber.

Dirt or Water in the Fuel—Dirt or water in the fuel is productive of many carburetor disorders; the one certain preventive is care in straining the fuel when filling the fuel tank; the remedy, periodical draining and flushing of the components of the fuel system, not neglecting complete disassembly and cleaning of the carburetor.

Freezing of Water in the Fuel—Water in the fuel eventually accumulates in the carburetor float chamber, where it impedes the flow of fuel to the fuel nozzles and hence causes imperfect running of the engine. In cold weather, this water will freeze and it may be impossible to start the engine; at best,

the latter will run badly. Apply hot cloths to the float chamber (**do not use a flame**), and, when thawed, drain and flush.

A quantity of water in the vacuum tank or fuel tank will produce the same result and should be treated in the same manner.

Filling the Vacuum Tank—Should the vacuum tank become empty, it can be refilled by closing the throttle and cranking the engine ten or fifteen seconds with the starter motor. Wait a minute or two and then attempt to start the engine.

If this treatment fails, forcibly strike the side of the vacuum tank with the fist; this will loosen the valves should they have jammed and will tend to dislodge any foreign matter on their seats. Crank the engine for ten or fifteen seconds, wait a minute or two, and again try to start the engine.

Should failure still result, remove the filler plug* and fill the vacuum tank with fuel. **Securely replace the plug** and start the engine.

Filling the Fuel Tank—In filling the fuel tank, always carefully strain the fuel through a chamois skin or fine metal gauze screen to remove water or other foreign matter. If this precaution is not taken, accumulations in the fuel tank of foreign matter are certain to result; carburetor or vacuum tank failure will inevitably occur.

Caution: Danger of Fire—When using a chamois skin to strain the fuel, particularly in cold weather, be careful that the funnel is held in thorough contact with the fuel tank. Under certain conditions, the flow of the fuel through the chamois skin generates static electricity, and were the funnel not in thorough contact with the metal of the tank a spark might result that would set the fuel on fire. There have been instances of such occurrences and due caution should therefore at all times be observed.

Carburetor Air Leaks—Gaskets are fitted to the joints between the carburetor and the inlet pipe and between the inlet manifold and the cylinders. Should these joints loosen or if the gaskets are broken, air will leak into the mixture and dilute it to such an extent that the engine will run badly or not at all; it is difficult—and sometimes impossible—to start an engine in this condition.

Air leaks are generally manifested by a whistling or hissing sound and are readily detected by the application of fuel to the joint under inspection. At the point of the leak, the fuel will be drawn into the inlet pipe or manifold and the speed of the engine will be momentarily increased.

Tightening the nuts and cap screws will remedy the condition, but, if this treatment does not bring the desired result, it will be necessary to install a new gasket.

A Jammed Float—If the carburetor float should cock in the float chamber by reason of the car standing at an angle, as on a roadside, for example, either too much or too little fuel will flow into the mixing chamber. In such

*G. G. tank, fuel filter.

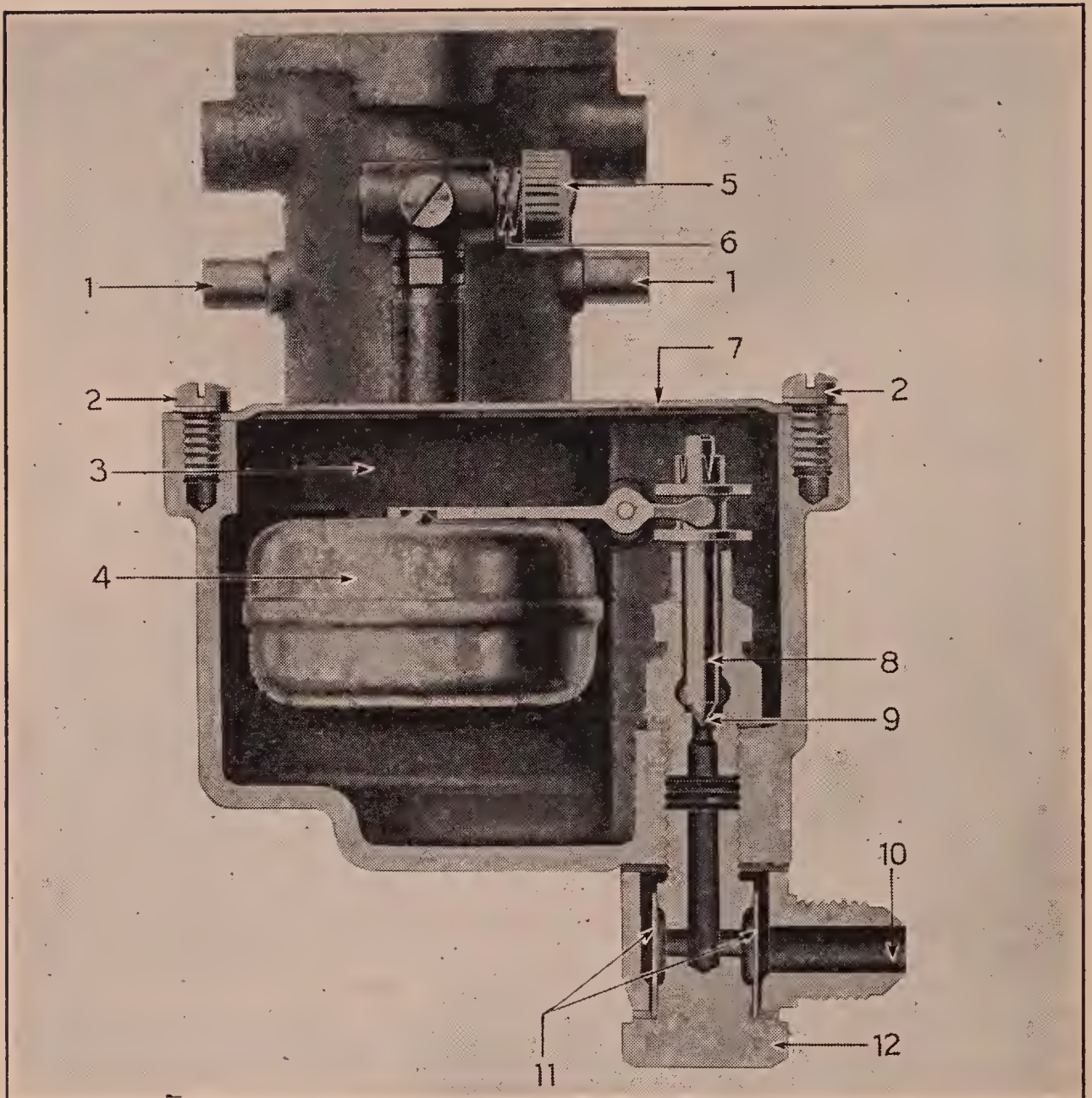


Fig. 43. Sectional View of Front of Carburetor

- | | |
|--------------------------------------|-------------------------------|
| 1 Throttle valve shaft | 6 Adjusting-screw lock-spring |
| 2 Float chamber cover screw | 7 Float chamber cover |
| 3 Float chamber | 8 Needle valve |
| 4 Float | 9 Needle valve seat |
| 5 Low speed (idling) adjusting-screw | 10 Fuel inlet |
| | 11 Fuel filter screen |
| 12 Drain (filter) plug | |

a contingency, the float needle valve (accessible through removal of the carburetor float chamber cover) should be raised and lowered a few times to release the float.

Float Needle Valve—Dirt between the float needle valve and its seat will prevent the valve from shutting off the flow of fuel into the carburetor. Dripping of fuel from the bottom of the carburetor will then occur and, if the engine is running, all the characteristics of a rich mixture will be present.

Lift the needle valve from its seat and hold it thus for a minute or two to permit the flow of fuel past the valve to wash the seat clean; then press it down against its seat and rotate it a few times. If this treatment fails, close the fuel shut-off cock and lift out the float and needle valve (be careful not to injure either). Unscrew the plug holding the fuel connection to the bottom of the float chamber and remove the filter screen. Wash out the float chamber and filter screen and carefully and securely replace all the parts.

If failure still results, hold the needle valve firmly on its seat with the fingers and very gently tap it with a light hammer or similar tool, raising and turning it occasionally. This treatment usually forms a new seat for the valve and stops the leaking.

If it becomes necessary to install a new needle valve, fit a new seat also; the float level must then be readjusted.

If the needle valve should be bent, as a result of rough treatment, it will not seat properly and the flow of fuel will not be shut off. It is best to have it straightened by a skilled mechanic or replaced.

Leaky Float—In the event that the mixture is continuously rich, test the carburetor float for leakage as outlined above with respect to a leaky vacuum tank float, the repair being made in the same manner.

Adjustment of the Carburetor—Do not attempt to adjust the carburetor until you are certain the engine has good compression in each cylinder, that the ignition apparatus is in perfect condition, that the flow of fuel from the vacuum tank to the carburetor is sufficient, that the carburetor choke is pushed all the way in, and that the engine is well heated.

When adjusting the carburetor, set all the spark plug gaps, using the gauge furnished for this purpose. Individual engines differ, however, and the car owner should therefore remember that the best results are had by setting the spark plug points slightly more or less than the gauge calls for, arriving at the correct setting for his particular engine by experiment.

Zenith Carburetor—The Zenith carburetor is fitted with but one manually variable adjustment—that of the idling device. This device is used to adjust the minimum low speed of the engine—to throttle it down; any other variation of the mixture that may become necessary can be accomplished only by changing the various fuel nozzles and should be attempted only by a thoroughly competent shop.

Turning the low speed adjusting screw (5, fig. 43) inward gives a richer mixture; outward, a leaner one.

Too rich a mixture, when throttled down, will be indicated by the engine running in a surging, irregular manner, with a strong odor to the exhaust and, possibly, black smoke. Open the throttle to clear the inlet manifold of the rich mixture, close it, and then turn the idling screw outward until the engine runs smoothly.

A lean mixture is manifested by the engine running in a jerky manner; possibly misfiring will occur; in extreme cases the engine will stop running. Turn the adjusting screw inward until smooth engine action is obtained.

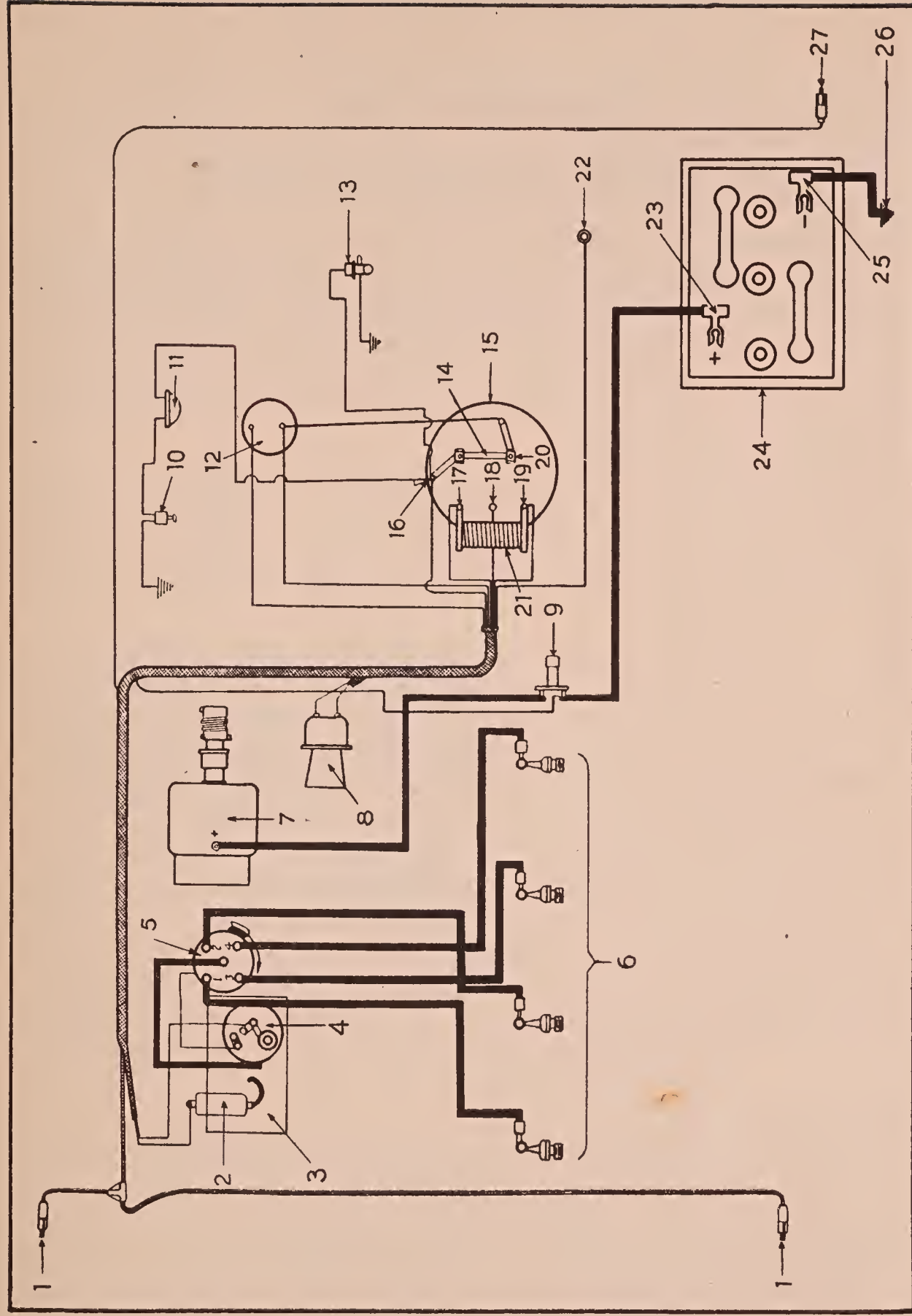
The best results are obtained by adjusting the low speed adjusting-screw and the throttle stop-screw simultaneously. Set a screw driver on the throttle stop-screw and, with the fingers of the other hand, turn the adjusting-screw inward or outward to enrich or lean the mixture, at the same time adjusting the stop-screw to gain the desired throttling speed. It will usually be found possible to lean the mixture as the throttle is brought closer to the closed position.

Adjusting the Throttle—An adjusting-screw is provided on the carburetor throttle lever to prevent the engine stopping when the throttle is closed. To adjust, close the throttle hand lever (on the steering column tube) and turn the adjusting-screw in to prevent the throttle from closing too far, or out so it can close farther. **Do not make this adjustment until the engine is well heated.**

Care of the Carburetor—Keeping the carburetor free from dirt and water is practically the only care necessary. This should be done periodically by removing the fuel connection, filter screen (11 and 12, fig. 43), and drain plugs (11, fig. 40), and cleaning them with fuel or compressed air. It is very important that the filter screen be replaced and that it be in good condition. If it is dirty, it will shut off the flow of fuel; if there are holes in it, solid foreign matter will pass through it and clogg the fuel nozzles. If necessary, the entire carburetor can be taken apart and cleaned and assembled without danger of changing any of the adjustments.

Fuel Knock—Under certain operating conditions and with the use of certain fuels, what is known as a fuel knock occurs. This knock, extremely hard to locate but quite rare, is caused by a peculiar condition set up in the cylinders when the mixture is admitted and burned. If, after all other causes of the knock have been eliminated, it still persists, another kind or brand of fuel should be tried. Usually, however, a fuel knock will disappear if the mixture is made slightly richer.

Most cases of improper functioning of the fuel system are due to foreign matter in the fuel. Periodical draining and flushing of the various parts comprising the system are most efficient preventives, particularly if periodically and carefully carried out.



- 1 Head-lamps
- 2 Reverse current cut-out
- 3 Generator
- 4 Ignition coil
- 5 Ignition distributor
- 6 Spark plugs
- 7 Starter motor
- 8 Warning signal
- 9 Dome-lamp switch
- 10 Dome-lamp
- 11 Ammeter
- 12 Instrument-lamp
- 13 Fuse
- 14 Ignition and light switch
- 15 Warning signal and dome-lamp connection
- 16 Head-lamp connection
- 17 Ignition connection
- 18 Tail-lamp connection
- 19 Battery connection
- 20 Resistance coil
- 21 Warning signal button
- 22 Battery positive connection
- 23 Storage battery connection
- 24 Battery negative connection
- 25 Battery ground connection
- 26 Tail-lamp
- 27

Fig. 44. Wiring Diagram

CHAPTER XIV

THE STARTING AND LIGHTING SYSTEM

The starting and lighting system comprises three major units, the uses of which are obvious: One, the storage battery (see chapter XV, part three, for details); two, the starter motor; and three, the generator. Beyond seeing that the two latter parts are periodically lubricated and the connections of the wires leading to and from them kept clean and tight, little attention is required. The storage battery, however, should be looked after much more frequently than the motor or the generator.

Care of the Generator—The generator should be occasionally examined to see that all connections are tight and that there is no undue wear of the moving parts. Disconnect the storage battery and remove the cover from the generator's rear end, thus exposing the brushes and commutator, and examine the parts mounted therein.

Cleaning the Commutator—The commutator, which is composed of a number of bars or segments of copper separated by thin pieces of mica, thus insulating the one from the other, may become blackened or rough. In this case, insert a flat, thin, wooden stick about 1 inch (25 mm.) wide, the end of which is covered with a clean piece of heavy woolen cloth. Press this against the commutator whilst the engine is running slowly to clean it.

If the commutator still remains black or rough, it should be smoothed with a piece of No. 00 fine sandpaper. Hold the sandpaper against the commutator by means of a flat stick wide enough to cover the entire width of the commutator, so that the latter is evenly smoothed; care must be taken to prevent the formation of grooves in it. Run the engine slowly and, at the completion of the operation, carefully blow or clean out all dust and particles of metal. **Under no circumstances use emery-cloth or -paper for this purpose.**

The Brushes—See that the generator-brushes make good contact with the commutator and that they are not noisy (squeaky). Examine the brush-holder springs to see that they have not become weakened; the spring tension should not be excessive, as this will cause heating and unnecessary wear; the brushes should make even contact with the commutator. If, when the engine is running, pronounced sparking is noticed between the brushes and the commutator, refit or replace the former; if this does not remedy the condition, remove the generator armature and turn it down in a lathe to eliminate the grooves or other irregularities.

Sparking might also be caused by the mica insulation between the commutator segments projecting above these segments; in this event, remove the armature and under-cut the mica.

Regulation of the Charging Rate—Should the generator not keep the battery sufficiently charged or if the electrolyte boils away (evaporates) too rapidly, the charging rate should be regulated.

Loosen the clamp-screw (on the rear upper side of the plate on the commutator end of the generator; see 7, fig. 45) holding the third-brush in position and swing the latter in the direction the armature rotates to increase the rate, and in the opposite direction to decrease it; securely tighten the clamp-screw. The armature turns to the left—anti-clockwise, when viewed from the rear or commutator end.

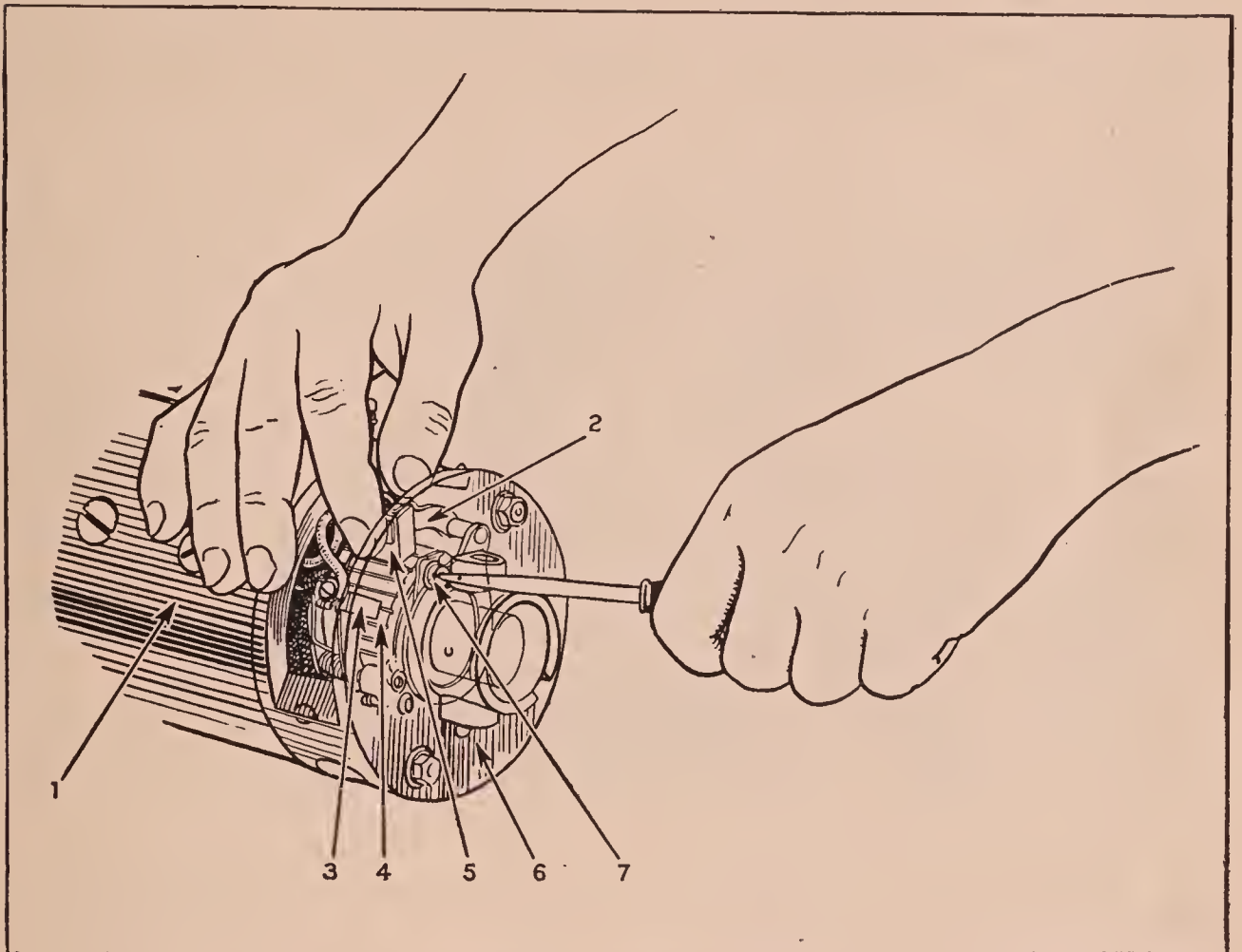


Fig. 45. Third-Brush Adjustment

- | | |
|--------------------------------------|----------------------------|
| 1 Generator | 4 Generator commutator |
| 2 Third-brush holder | 5 Third-brush |
| 3 Generator-brush | 6 Generator rear end-plate |
| 7 Third-brush adjustment clamp-screw | |

This adjustment should be made with the engine running at a sufficiently high rate of speed to drive the car, on high gear, at 25 miles (40 km) an hour. Connect an ammeter in the charging circuit and carefully note the charging rate; neither the lamps nor the horn should be in use when making this adjustment. Generation of charging current should commence at a car speed, on high gear, of approximately 10 miles (16 km.) an hour*; with the lights turned off and the horn not in use, the charging rate should not exceed 16 to 18 amperes when the generator is hot.

Refit the Brushes—It may be necessary to refit the third-brush to the generator commutator after changing its position in adjusting, to ensure its being in thorough contact; the other brushes are fitted in the same manner.

*Sufficient power should be generated at this speed to supply the lights and ignition.

Insert a strip of fine sand-paper or sand-cloth (**DO NOT USE EMERY**), slightly wider than the brushes, so that it snugly encircles the commutator, with the rough side next to the brushes. Seat (fit) all three generator-brushes by drawing the sand paper back and forth a few times. Clean out all particles of sand and metal.

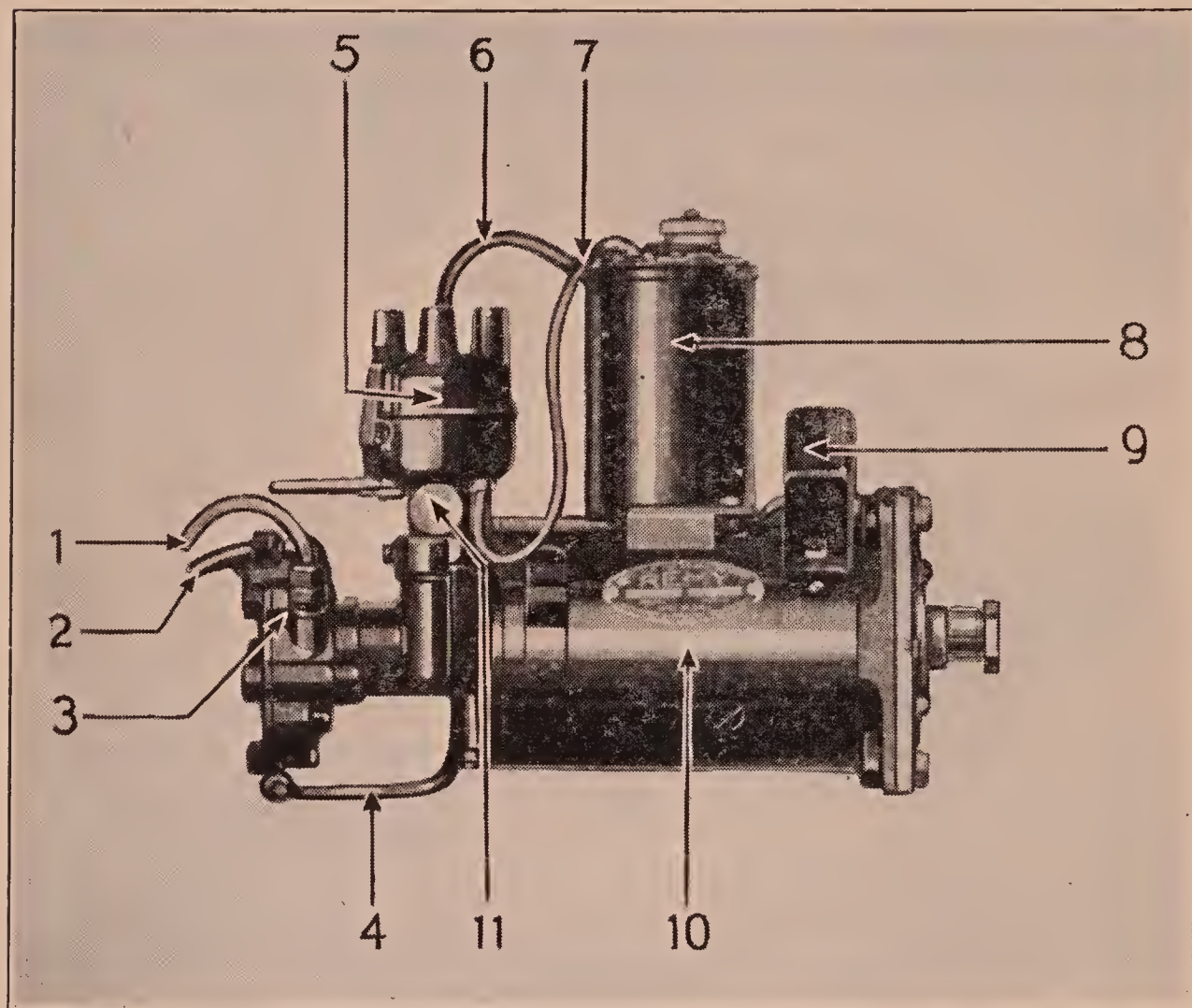


Fig. 46. Generator and Oil Pump

- | | |
|--------------------------|----------------------------------|
| 1 Oil suction pipe | 6 Cable, ignition dis- |
| 2 Oil distributor pipe | tributor to coil |
| 3 Oil pump | 7 Wire, ignition breaker to coil |
| 4 Oil pressure gauge and | 8 Ignition coil |
| center main bearing | 9 Reverse current cut-out |
| pipe | 10 Generator |
| 5 Ignition distributor | 11 Lubricator |

It is most advisable to have such operations as smoothing the commutators with sand paper, refitting brushes, under-cutting mica, and regulation of the generator output attended to by a reliable shop. Such work calls for skill and expert knowledge and should never be attempted by a novice, as it most likely will result to his disadvantage.

The Starting Motor—The starting motor requires the same care and attention as the generator.

Starting Motor Drive—The mechanism on the rear end of the starting motor armature shaft, which automatically engages and disengages the starting motor pinion with the fly-wheel gear when the starting motor is set in operation to crank the engine, should be occasionally examined. It will be noticed that a spring is fitted to this mechanism, the function of which is to absorb the shock of suddenly meshing the pinion with the fly-wheel gear in cranking the engine. It sometimes happens that the bolt holding this spring in position loosens, and it should, in such an event, be tightened. Due to improper use of the starter, the spring may become bent out of shape; should this occur, its replacement is the best repair.

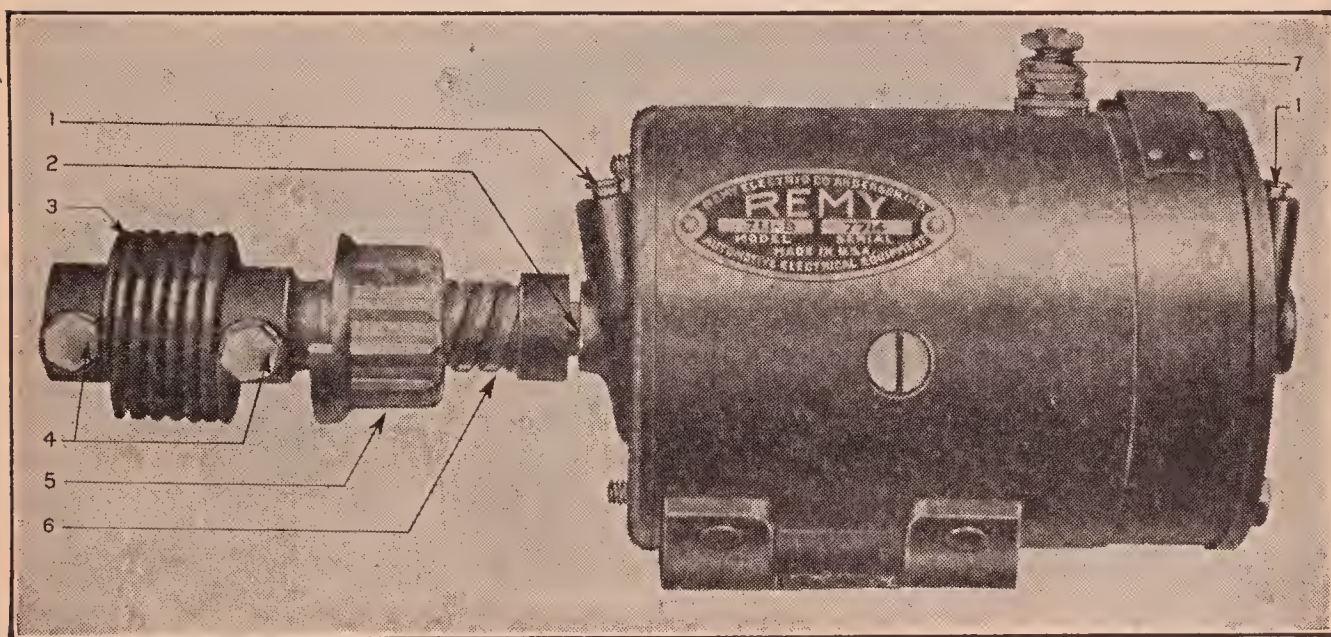


Fig. 47. Starting Motor

- | | |
|------------------|---|
| 1 Lubricator | 5 Starting motor pinion |
| 2 Armature shaft | 6 Threaded shaft |
| 3 Spring | 7 Connection, starting switch to starting motor cable |
| 4 Spring bolts | |

Vibration may cause the bolts holding the starting motor to the engine to loosen, when the starting motor very likely will shift slightly out of alignment with the fly-wheel and cause the starting motor pinion to mesh improperly. Under these conditions the pinion will engage violently with the fly-wheel gear when the engine is being cranked by the starting motor and considerable noise will ensue. The remedy is properly to align the starting motor with the fly-wheel and then securely to tighten the bolts.

Caution—Under no circumstances apply oil or grease or other form of lubricant to the threaded shaft on which the starting motor pinion operates. This shaft should at all times be free from any lubricant or from any other matter that would cause it to become sticky or gummy, as this would prevent proper action. If this condition should arise, thoroughly wash the pinion and the threaded shaft with gasoline or kerosene.

Never apply lubricants of any kind to the commutator of either the starting motor or the generator, as no lubricant is required at these points.

Reverse Current Cut-out—The function of the reverse current cut-out (sometimes called the circuit-breaker or relay; see fig. 48) is automatically to disconnect the storage battery from the generator when the voltage of the latter is less than that of the former; this is the case when the engine is operating at a low rate of speed, or when it is not running.

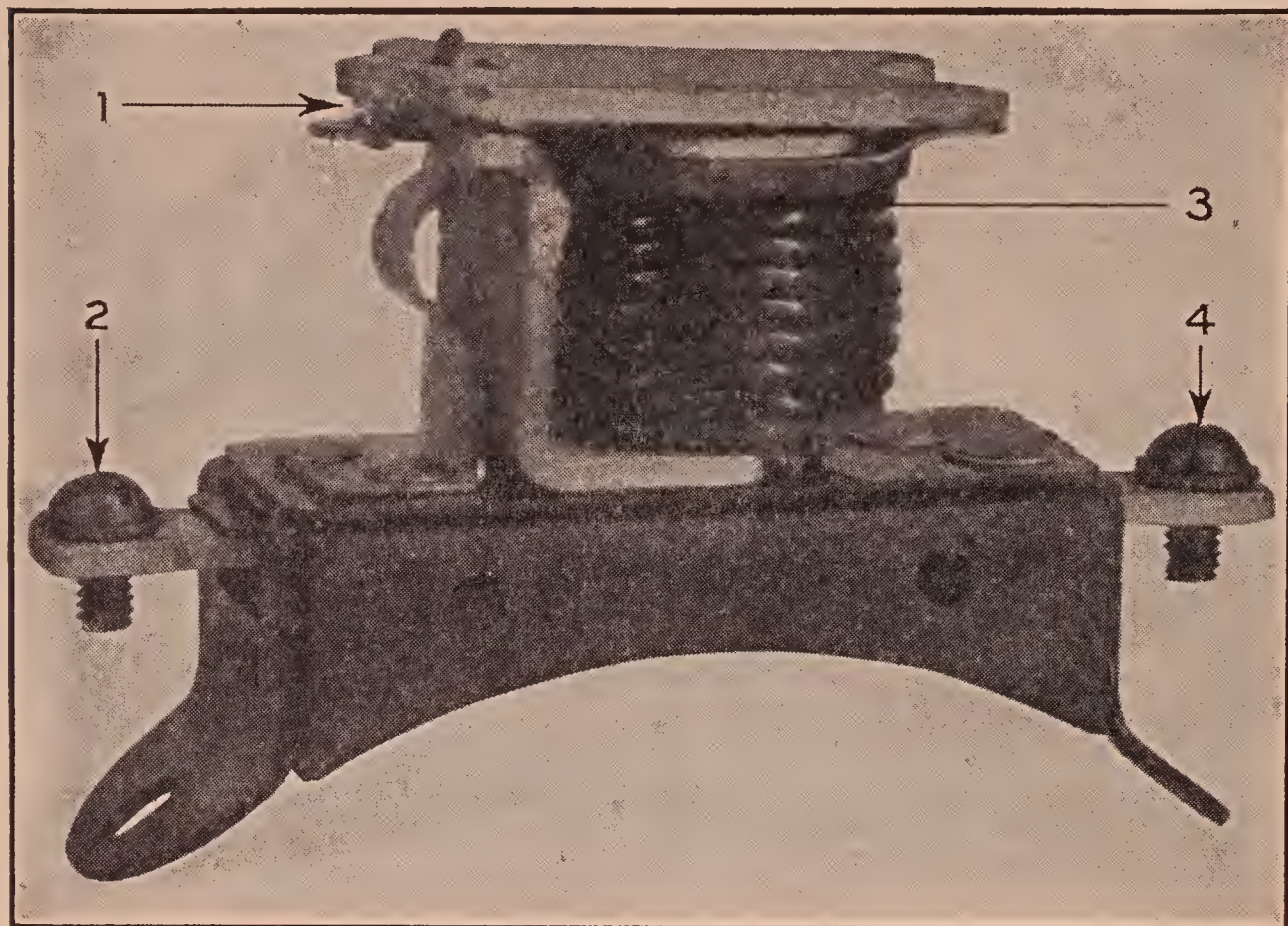


Fig. 48. Reverse Current Cut-out

- | | |
|-------------------------------|------------------------|
| 1 Contact points | 3 Outer winding |
| 2 Battery positive connection | 4 Generator connection |

The reverse current cut-out is entirely automatic in action. It requires no lubrication, and but little attention beyond seeing that the wires leading to it are tight. If for any reason it should fail to operate properly, it should be adjusted at a competent shop or returned to the manufacturer. Should it be removed from the car, **the engine must not be operated until the generator is grounded** (see p. 134).

Every 1,000 miles (2,000 km.), remove the cover from the cut-out and examine the contact points, as they may have become burned or pitted.

Burns or pits can be removed by means of a fine jeweler's or Swiss file or a piece of fine (No. 00) sandpaper. Insert the file or sandpaper between the contact points and, pressing the points lightly together, pull it straight out. This operation should be repeated until the pits and burns have been removed. Exercise every care that perfectly square, clean, flat contact surfaces are obtained. Do not move the file or sandpaper back and forth

between the points, as this has a tendency to round their edges; convex rather than square surfaces result.

The contact points should open from 0.010" to 0.016" (0.25 to 0.4 mm.).

The cut-out contact points will chatter if—

1. The points come together too soon;
2. The polarity of the generator is reversed;
3. The battery terminals are reversed.

To prevent needless burning of the cut-out contact points before the generator automatically changes its polarity, correct the latter by closing the contact points when the engine is not running. **See that the contact points separate when they are released.**

The cut-out contact points will not close if—

1. They are dirty;
2. The generator shunt winding is open (loose or broken);
3. The cut-out is incorrectly adjusted;
4. The generator is out of order;
5. The generator commutator is dirty;
6. The generator-brushes are sticking;
7. The wire from the generator to the battery is disconnected or broken.

Items 1, 2, 3, and 7 immediately above will cause the generator-windings to burn out.

The Ammeter—The amperemeter (usually called ammeter) is the current measuring instrument of the starting and lighting system; it is mounted on the instrument board under the observation of the driver.

The dial or face of the meter is divided into two parts, one marked CHARGE and the other DISCHARGE. When the generator is charging, that is, when it is generating electricity, the hand or pointer will swing a proportionate distance across the CHARGE side of the dial; but if current is being consumed, as when the lamps are in use, the hand will swing across the DISCHARGE side.

Under certain conditions, however, the ammeter may still show CHARGE when the lamps are in use, or the hand may register "O"; this condition is caused by the charging rate of the generator exceeding the current consumption or equalling it.

When the engine is not running, there is, of course, no generation of current. In this case, any discharge shown on the ammeter indicates actual consumption—the amount of current then flowing from the storage battery.

The ammeter should read "O" when the engine is not running and all lights, etc., are turned off. Under these conditions, any other reading indicates:

1. Ammeter reading incorrect;
2. Short-circuit or ground in wiring system or switch;
3. Ammeter is defective.

The ammeter will show a discharge at low engine speeds, but it should show a charge when the car is driven at more than 10 miles (16 km.) an hour, with the lights, horn, etc., not in use. If it shows a discharge with the engine at rest and the lights and horn not in use, immediately investigate so as to prevent discharge of the storage battery.

With all lights on, a speed of approximately 10 miles (16 km.) an hour will be required to show a charge. At lower speeds than this the ammeter may show a discharge.

If the ammeter never shows a charge, look for:

1. Injury to the ammeter;
2. A short-circuit may prevent the current passing through the ammeter;
3. The reverse current cut-out may be out of order;
4. An open-circuit (a broken wire or loose connection) between the generator and the battery;
5. Generator out of order.

If at any time the ammeter shows a discharge in excess of 15 amperes, the wiring system should be examined for a short-circuit.

If the ammeter shows a charge with the lights in use and the engine not running, it indicates:

1. Battery terminals reversed (improperly connected—the **negative battery terminal must be connected to the frame**);
2. Ammeter connections reversed.

Should the ammeter be removed from the instrument board, do not run the engine without first having connected together the two wires that lead to it.

Improper Functioning of the Generator—If the battery is not being properly charged, the following should be looked for:

1. Examine all connections and see that they are tight and clean;
2. Adjust charging rate;
3. See that the generator commutator and brushes are clean;
4. See that the generator-brushes make good contact with the commutator;
5. Examine the brush springs to determine if they are holding the brushes firmly against the armature;
6. See that all nuts and screws are tight.

If the generator is working properly, the following should be looked to:

1. See that all nuts and screws are tight;
2. See that the connections of all wires are clean and tight;
3. See that the ammeter is in proper order (this can be done by turning on the lights with the engine at rest; if the ammeter does not register, it should be repaired or replaced);
4. Examine the battery (see chapter XV, part three), as it may be at fault;

5. Examine the wiring for a ground (in this case an end of a wire may be touching a metallic part of the car other than that its terminal is attached to, or insulation may have worn through, permitting the then exposed wire to make contact with some other metal part);
6. Look for a broken or disconnected wire between the generator and storage battery;
7. Examine the reverse current cut-out contact points, to see that they come together when the engine is running.

Improper Cranking of the Engine—If the motor fails properly to crank the engine, the fault may lie in a partly or completely discharged battery* ; proceed as outlined in chapter XV, part three. The following should be examined, also:

1. See that all connections, especially those on the battery and the switch, are clean and tight;
2. See that the starting switch is clean and that it makes good contact (if in doubt, place a screwdriver or similar tool across the two terminals on the bottom of the switch; if the starting motor then operates the fault lies in the switch, but if it does not operate, the fault lies elsewhere);
3. See that the starting motor brushes make good contact with the commutator and that the latter is clean and free from oil;
4. See that the starting motor pinion has not jammed;
5. See that the starting motor pinion engages properly with the fly-wheel gear;
6. See that the storage battery is in good order;
7. Examine the wiring in the starting circuit to see that none of the wires is broken, nor any of the insulation worn through, thus grounding (short-circuiting) a wire;
8. See that the gearshift lever is in neutral.

If the starting motor continues to run after the starting switch has been released, the latter is in need of adjustment.

Starting Motor Pinion Jams—In the event that the starting motor pinion should jam in mesh with the fly-wheel gear, it can be released by tapping it rearward with a block of wood and a hammer. If this should fail, move the gearshift lever into high speed and push the car backward and forward.

This condition is a result of improper alignment of the starting motor with the fly-wheel gear.

Lamps—If a lamp fails to light, it very likely is due to a burned-out lamp bulb. However, such a condition may result from some other cause; if replacing the bulb fails to remedy the difficulty, examine the fuse at the back of the lighting and ignition switch. If the fuse is at fault, replace it with a new one. If any doubt is felt about the condition of the fuse, test it by inserting a small

*Using the starter with the battery in a state of low charge will cause the starting motor to operate at less than normal speed and will damage the commutator through excessive sparking.

piece of steel or copper wire between the two clips that hold the fuse in place. If the lights then still fail to burn, the trouble lies elsewhere than in the fuse.

The fuse is of 15 amperes capacity.

Examine the wires for any breaks or worn insulation that would cause a short-circuit or a ground. The switch connections, as well as the interior of the switch, should also be inspected. If the battery is completely discharged, or nearly so, the lights will burn very dimly, or perhaps not at all.

When the head-lamp reflectors become tarnished, take great care in repolishing them to prevent scratching. The reflectors are silver-plated and very highly finished, and are easily scratched even when cleaned with a soft material. (See chapter XIX, part three, for details on cleaning and polishing.)

Lamp Bulbs—The candle-power, voltage, etc., of the lamp bulbs are as follows:

Head-lamp.....	6-8 volts;	21 c. p.; single contact
Instrument-lamp.....	6-8 volts;	2 c. p.; single contact
Tail-lamp.....	6-8 volts;	2 c. p.; single contact
Dome-lamp.....	6-8 volts;	2 c. p.; double contact

If lamps of a higher candle-power than those listed above are used, the current consumption will be increased and the battery will discharge more rapidly. If the car owner considers it necessary to have greater illumination and therefore uses larger lamp bulbs, it may be necessary to have the charging rate of the generator increased.

Do not remove the motor or generator from the engine nor attempt to change any of the connections at the back of the ignition and lighting switch or the ammeter without first having disconnected the cable from the negative terminal of the storage battery—the cable connected to the frame.

In the event that you should run the engine with the battery* removed from the car or disconnected from the generator, it is vitally important that the latter be grounded or short-circuited by a piece of wire connected between the generator terminal† and the reverse current cut-out mounting screw. Under no circumstances should the engine be run until this is done. Failure to observe this precaution will burn out the generator windings and ruin it.

Do not apply lubricants of any kind to the commutators of the motor or generator, as no lubrication is required. As a matter of fact, the presence of a lubricant on the commutators will cause faulty operation of the motor or generator.

The wisest rule to follow in the care of electrical apparatus is not to tinker with it or any of its adjustments. Attention should be confined to lubrication, cleaning the various parts, and to seeing that all the connections are clean and tight, and that the wires of the various circuits are protected from injury, such as chafing or exposure to oil, grease, or water.

* This caution applies to removal of the reverse current cut-out, also.

† On the bottom side of the generator.

CHAPTER XV

THE STORAGE BATTERY

What is a Storage Battery?—Possibly the term storage battery—which is in reality a misnomer—has given rise to the prevailing misconception of its true nature, because storage implies the storing away of something, such as storing water in a tank, to remain there until needed.

Electricity is not stored away in a storage battery until needed. It is caused to flow into the battery and out of it by means of the two wires attached to it, but none of the electricity stays there; it merely causes a certain change to take place within the battery. Hence, when the battery is used, this change reverses itself and in doing so gives forth electricity somewhat less in amount than the volume of current used in charging it, thus restoring it to its original—uncharged—condition.

An Electro-Chemical Machine—Many people are under the impression that a storage battery receives and stores up electricity during the charging process. On the contrary, charging a storage battery sets up a certain electro-chemical action between its positive and negative plates in the presence of an electrolyte—a battery solution composed of pure water and pure sulphuric acid in certain proportions. This action does not store up electricity; **it produces a chemical change in these plates.** Thus, when a circuit (an uninterrupted path for the electric current to follow) is established between the battery terminals, as when a battery is discharged—when electricity is taken from it—the material with which the plates are filled changes back to its original condition and an electric current is given off. Electricity is generated in the battery in as full a sense as in an electrical generator.

Warranty—Exide batteries are guaranteed by the manufacturers, the Electric Storage Battery Company, Philadelphia, Pennsylvania, U. S. A., to be free from defects in material and workmanship.

At any time within three months from the date of delivery of the car to the purchaser any battery which may prove to be defective or incapable, when fully charged, of giving its rated capacity, will be repaired or replaced free of expense on receipt, transportation charges prepaid, at any Exide battery depot or authorized Exide battery service station. This guarantee does not cover the free charging of batteries, nor the making good of damage resulting from continued lack of charge, nor from failure to keep the plates covered with solution by filling the cells from time to time with pure water. No claims on account of alleged defects can be allowed unless made within three months of date of delivery of the battery to the purchaser, and the right is reserved to refuse to consider claims in the case of batteries opened by other than authorized battery service stations.

The Willard Storage Battery Company, of Cleveland, Ohio, U. S. A., have adopted the following service policy for owners of cars equipped with Willard threaded-rubber-insulation batteries:

1. They will insure every Willard threaded rubber insulation battery for three months from the date of purchase, provided the battery is registered at the nearest Willard service station or at the nearest dealer authorized by the service station to do such work.

If any repairs are necessary during this three months period, for any reason whatsoever, they will be made without charge to the car owner by the Willard service station or by any dealer authorized to do such work. Any imperfect material or workmanship in a Willard battery will manifest itself in the battery's performance within the first three months of ownership and claims must be made within that period.

Recharging or the use of rental batteries is not classed as repairs and such services will be charged to the car owner.

2. Threaded-rubber-insulation in Willard batteries will last the life of the plates or it will be replaced without charge by any Willard service station or by any dealer authorized to do such work.
3. Repairs not included in the above will be charged to the car owner.

Registration of Batteries—Car owners are earnestly urged to co-operate with the battery manufacturer by taking their cars as promptly as possible after receipt to the nearest Exide or Willard battery service station in order that the battery may be registered and its condition and installation checked. No charge is made for this inspection.

Battery Charging—Three conditions must be met in order successfully to charge storage batteries:

1. Direct current must be used (if only alternating current is available, some device, such as a rectifier, for changing alternating to direct current, is necessary);
2. It must be determined which of the charging wires is positive and which negative, because in order to charge the battery the current must flow through it in but one direction;
3. A resistance or other form of current regulating device must be used to keep the charging rate at the proper figure, as too high a rate will seriously injure the battery.

Positive and Negative Polarity Test—The polarity—the direction in which the current flows—of any direct current power line can be determined by dipping the ends of the two wires to be tested into a glass of water in which a teaspoonful of common table salt or a small quantity of electrolyte from the battery has been poured. Do not let the ends of the wires come together (make contact). Fine bubbles of a colorless gas will be given off at the negative wire. In making this test, observe both wires very carefully, for a **small quantity of bubbles will appear on the positive wire**, also.

A voltmeter can also be used to make this test.

After the polarity of the charging circuit has thus been determined

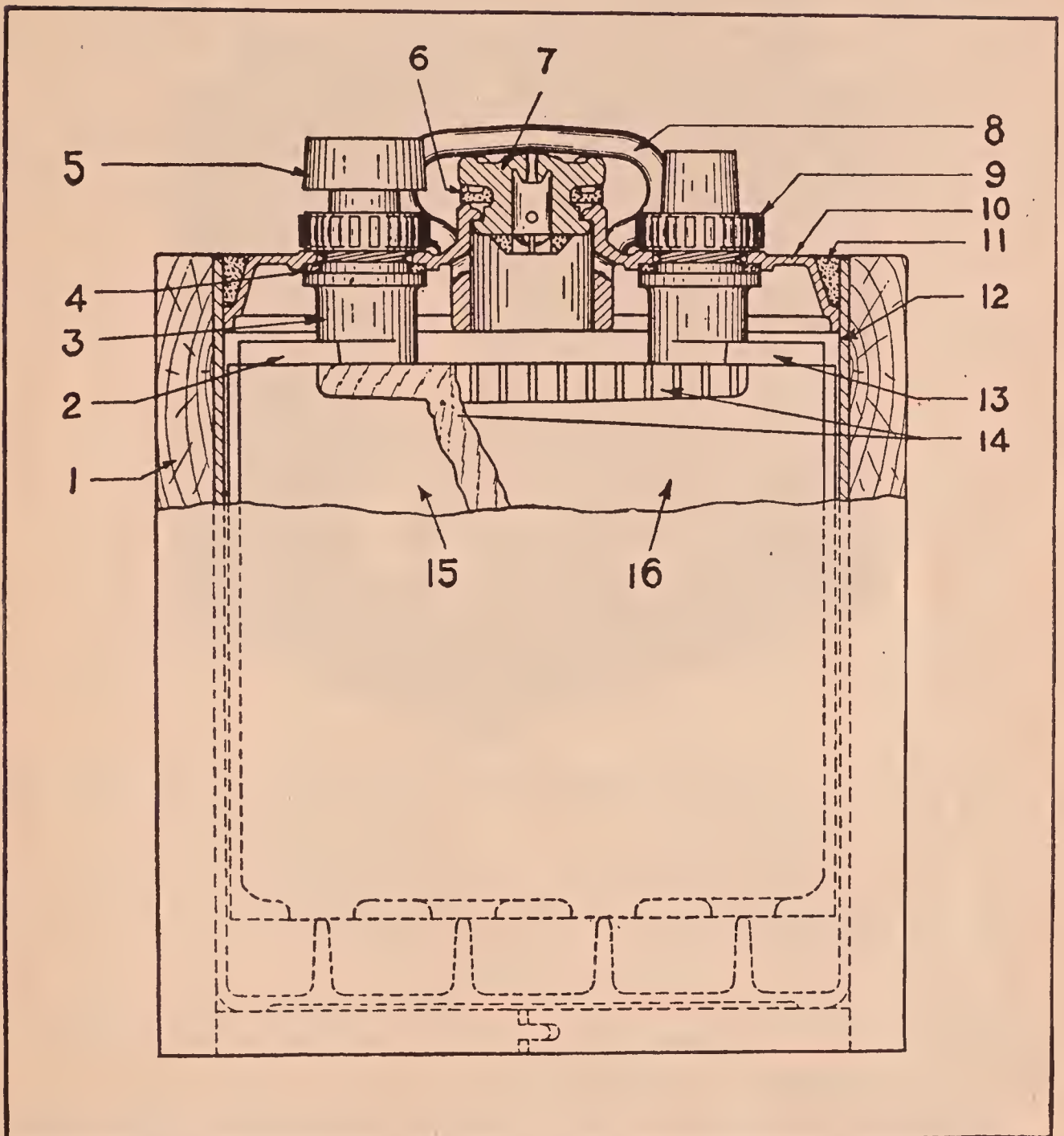


Fig. 49. Exide Storage Battery

- | | |
|------------------------|---------------------------|
| 1 Wood case | 9 Sealing nut |
| 2 Negative strap | 10 Cell cover |
| 3 Post | 11 Sealing compound |
| 4 Post gasket | 12 Rubber jar |
| 5 Cell connector | 13 Positive strap |
| 6 Filling plug gasket | 14 Wood separator |
| 7 Filling or vent plug | 15 Negative plate (grey) |
| 8 Handle | 16 Positive plate (brown) |

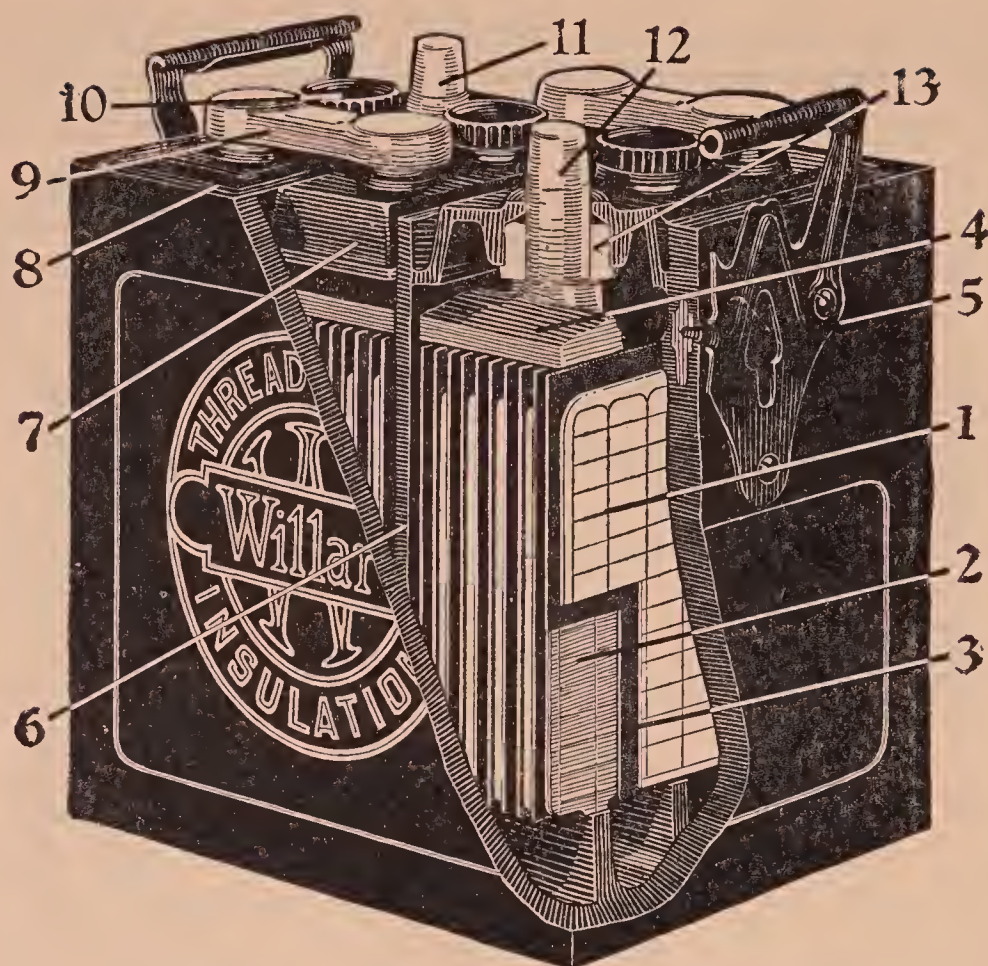


Fig. 50. Willard Storage Battery

- | | |
|--------------------------|-----------------------|
| 1 Negative plate | 7 Hard rubber cover |
| 2 Positive plate | 8 Sealing compound |
| 3 Insulation (separator) | 9 Top connector |
| 4 Connecting strap | 10 Vent plug |
| 5 Battery box | 11 Negative post |
| 6 Hard rubber jar | 12 Positive post |
| | 13 Rubber gasket seal |

permanently mark each wire, using “+” on the positive and “—” on the negative, so as readily to distinguish them.

Resistance Apparatus—When charging the battery with direct current taken from lighting, railway, or power lines (the usual sources of power for charging purposes), some form of resistance is necessary to regulate the charging current. A number of lamps is the cheapest and simplest resistance to use, a requisite number being connected in parallel (see fig. 51). Screwing the lamps in or out of their sockets, so that they are burning or out, varies the charging rate within sufficiently close limits.

The charging rate for one lamp burning is, roughly, the wattage of the lamp divided by the voltage of the charging line. For example, a 50-watt, 110-volt lamp will give a charging rate of about half an ampere; or a 110-volt 100-watt lamp will ensure a charging current of about one ampere; hence, two 100-volt, 100-watt lamps equal a charging rate of about two amperes.

Use Ordinary Carbon Lamps—Ordinary carbon filament lamps are the most satisfactory for this purpose because they are cheaper and have a

higher resistance. They are, however, rated in candle-power and not in watts. A 16 candle-power, carbon filament lamp gives a charging rate of about one-half an ampere of charging current.

Figure 51 shows a six volt battery being charged by means of four 100-watt tungsten filament lamps or four 32 candle-power of the carbon variety, connected in parallel. This combination provides a charging rate of about four amperes on a 110-volt circuit. Figure 51 also shows the connections to be

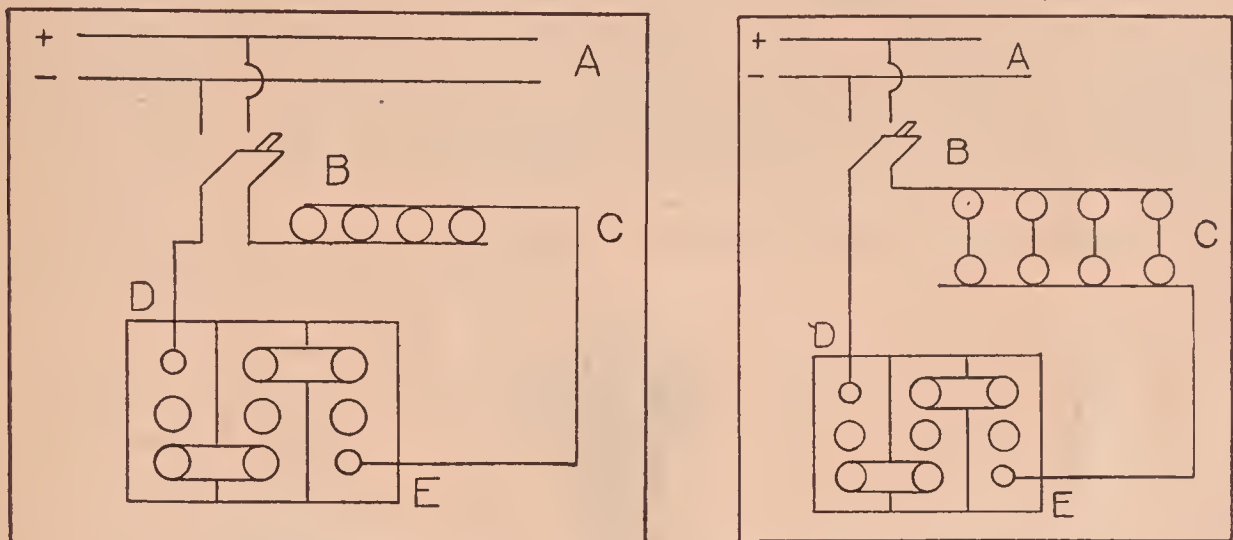


Fig. 51. Battery Charging

Left—110-volt circuit, lamps in parallel. **Right**—220-volt circuit, lamps in series-parallel. A. Charging circuit. B. Switch. C. Lamps. D. Negative connection. E. Positive connection.

used if the line voltage is 220 and only 110-volt lamps are available for use. In such a case, employ two lamps connected in series, in four groups, making eight lamps in all. This connection gives a charging rate of four amperes.

Measure the Charging Rate—Connect an ammeter in the charging circuit to ascertain the charging rate.

Charging with Delco-Light—It is possible to charge a motor car battery from an isolated farm lighting plant, such as the Delco-Light, if desired. Figure 52 shows the method of connecting a six volt battery.

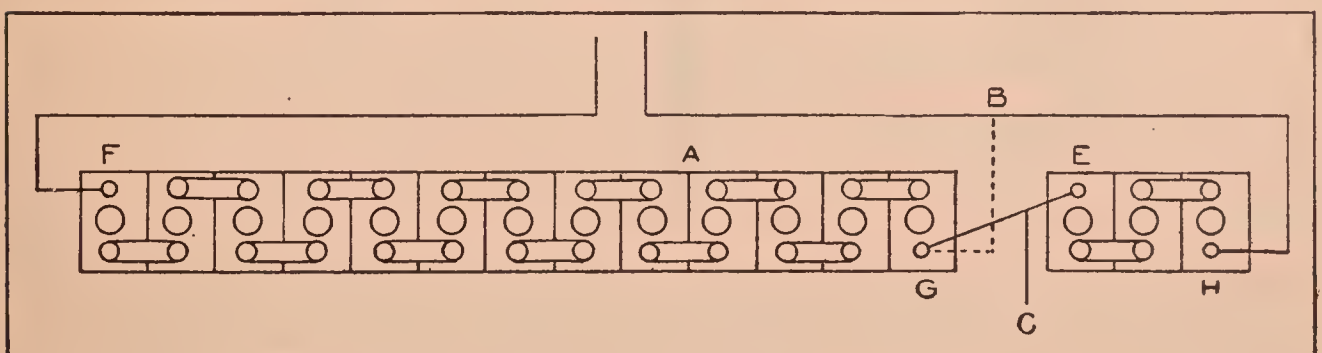


Fig. 52. Charging Battery with Farm Lighting Plant

Disconnect wire "B" from "G" and connect to "H," as shown.

Connect "G" with "E" by wire "C," as shown.

Battery Terminals: Positive—Negative—All batteries have their terminals plainly marked. The positive terminal is marked "POS" or "P" or "+"; the negative is marked "NEG" or "N" or "—." In putting a battery on charge, always connect the positive terminal of the battery to the positive, and the negative terminal of the battery to the negative charging wire. Failure to observe this precaution is very likely to ruin the battery, due to changing the polarity of the battery plates.

Remove Vent Plugs—When a battery is placed on charge, remove the vents or filling plugs. After charging for several hours, gas bubbles will appear on the surface of the electrolyte; this is known as gassing. During charging, all cells should gas freely; if a cell does not gas, it indicates that that cell is not charged or that there is some internal trouble.

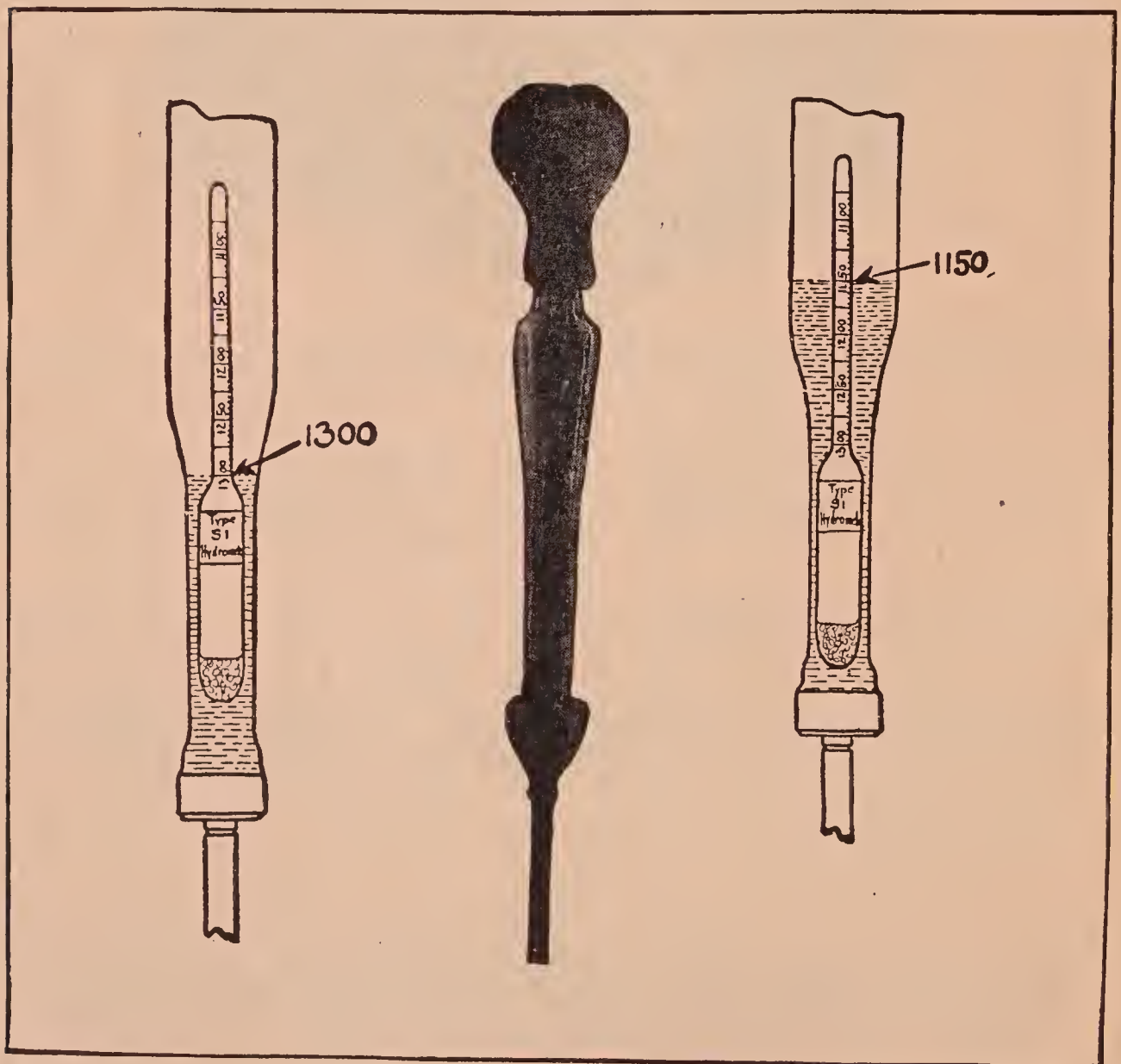


Fig. 53. Battery Hydrometer

Left—Specific gravity reading, fully charged battery. Center—Battery type syringe hydrometer. Right—Specific gravity reading, discharged battery.

Gassing—When the charging has proceeded to a point at which all cells are gassing freely, the charging current should be reduced. If this is not done, excessive heat will develop and the battery may be seriously injured and possibly ruined. The temperature of a battery on charge should be carefully watched; if it rises above 110° F. (43.3° C.), entirely cut off the current until the battery is cool or reduce the charging rate.

Correct Charging Rate—The correct charging rate, starting and finishing, will be found stamped on a plate attached to the side of the battery-case.

Hydrometer Readings—Hydrometer readings should be taken at least three times a day during charging. When hydrometer readings have remained the same after four hours of continuous charging, the battery may be assumed to be fully charged. In this case the specific gravity should be between 1.280 and 1.300. If any of the cells do not come within these limits after charging, a battery expert should be consulted.

Add Distilled Water—During the charging process all the cells should be plentifully supplied with distilled water, but do not add so much water that the solution boils or flows over the top of the battery. **It should be remembered in this connection that hydrometer readings taken immediately after water has been added to a battery are worthless,** as the water has not had time in such a case thoroughly to mix with the electrolyte. Wait at least one hour after filling with water before taking hydrometer readings.

Gassing—Caution—Gassing is caused by minute bubbles of hydrogen gas being given off during the charging process. As hydrogen gas when mixed with air is highly explosive, do not let a flame or a spark come close to the vent holes of the battery whilst charging or for several hours after taking the battery off charge, lest a serious explosion occur.

Specific Gravity in Hot Climates—In climates where the average temperature is around 90° F. (32° C.) or more, it is recommended that the specific gravity of a fully charged battery be maintained at 1.250 instead of from 1.280 to 1.300. This, it will be noted, is 30 to 50 points lower than standard.

In sections where extremely high temperatures prevail throughout the year, an even lower specific gravity is desirable—from 1.200 to 1.220.

This change in specific gravity is best accomplished by charging the battery at a low rate and then replacing the electrolyte with one of a lower specific gravity; **it is not to be made if low or freezing temperatures prevail even for part of the year.**

Battery in Winter—Because of the greater demand on it, a battery is generally in a more or less discharged condition in winter and the owner should therefore very carefully watch its condition, taking specific gravity readings of the electrolyte oftener than in summer.

Danger of Freezing—A battery will freeze as indicated below:

$\frac{1}{4}$ discharged	1.255 specific gravity	-60° F. (-51° C.)
$\frac{1}{2}$ discharged	1.220 specific gravity	-25° F. (-32° C.)
$\frac{3}{4}$ discharged	1.185 specific gravity	8° F. (-22° C.)
Discharged	1.150 specific gravity	5° F. (-15° C.)



Fig. 54. Plates from Frozen Battery

The Battery Out of Service—Since a battery will discharge if left idle, it should have special attention when the car is laid up for any protracted period; it is best to send it to a battery repair shop for storage whilst the car is out of use. If the services of such a shop are not conveniently available to the car owner, it is suggested that he proceed as follows:

At intervals of two weeks, run the engine until the specific gravity of the solution is 1.250 or higher. If this is done regularly every two weeks, it will be necessary to run the engine only about one hour each fortnight. To charge the battery properly under these conditions, the engine should be run at a speed equal to a car speed of approximately 20 miles (32 km.) an hour on high gear.

If current (power or lighting) is available, the battery can be maintained in good condition by charging every two weeks in the manner outlined on page 136. A twelve-hour or overnight charge every two weeks will suffice to keep the battery in excellent condition. In using a power or lighting circuit for charging the battery when it is mounted in the car, disconnect the heavy cables leading to it; only the wires of the outside charging circuit should be connected.

To take a Specific Gravity Reading—To take a specific gravity reading, the following directions should be observed:

1. Remove the vent plugs from the cells;
2. Compress the bulb of the hydrometer syringe and insert its end through a vent hole into the electrolyte;
3. Release the bulb until sufficient solution is drawn from the cell into the hydrometer tube to cause the hydrometer float to rise (see fig. 53);
4. Hold the syringe in a vertical position so that the float does not touch the sides of the tube; the specific gravity reading is taken on the float scale on a line with the top of the solution;

5. Compress the bulb and let the electrolyte run back into the same cell from which it was taken;
6. Replace the vent plugs.

Test each cell in this manner.

Mixing Electrolyte—The proper proportions of sulphuric acid and water used in mixing storage battery electrolyte is given in the following table:

Specific Gravity	Parts of Water by Volume to One Part of Pure Sulphuric Acid (Sp. Gr. 1.835)
1.200	4 $\frac{1}{3}$ parts of water to 1 part of acid
1.225	3 $\frac{2}{3}$ parts of water to 1 part of acid
1.250	3 $\frac{1}{4}$ parts of water to 1 part of acid
1.275	2 $\frac{3}{4}$ parts of water to 1 part of acid
1.285	2 $\frac{2}{3}$ parts of water to 1 part of acid
1.300	2 $\frac{1}{2}$ parts of water to 1 part of acid
1.335	2 parts of water to 1 part of acid

In mixing electrolyte, acid should always be poured into water—never water into acid, as this latter practice may cause serious personal injury. Care must be exercised, also, that only acid and water of good quality are used. Only distilled water should be employed, and the acid should be secured from a reliable source.

Distilled or Pure Water—By distilled or pure water is meant water which contains nothing injurious to the battery. Water may be excellent for drinking and yet contain some substance that will harm the battery. Distilled (not merely boiled) water; melted artificial (not natural) ice; rainwater (if obtained in the open country from a clean place or shingle covered roof); generally any of these are satisfactory. Water for battery use should be kept only in clean, covered vessels of glass, china, earthenware, rubber, or lead; under no circumstances should other kinds of vessels be used.

Never add acid to the electrolyte in an attempt to bring up its specific gravity, or, rather, to charge the battery. It is true that this practice will increase the specific gravity of the electrolyte, but it can not **charge** the battery; in fact, it will only damage it. Under these conditions, a cell may read 1.300 and still be completely discharged. If, however, any of the electrolyte in a cell is accidentally spilled, replace it with a mixture of acid and water of 1.300 specific gravity.

Add Distilled Water—Pure or distilled water must be added often enough to keep the battery plates covered, for if they are exposed for any length of time, serious damage will result.

The best rule to follow is to remove the vent plugs once a week without fail and add pure water if the tops of the plates are exposed; in very hot weather, and particularly on long runs, this should be done daily—every 200-250 miles (400-500 km.).

It is of the highest importance that the car owner, or his chauffeur, adhere strictly to this rule. Do not add so much water that the battery solution will boil up over the outside of the battery whilst it is being charged.

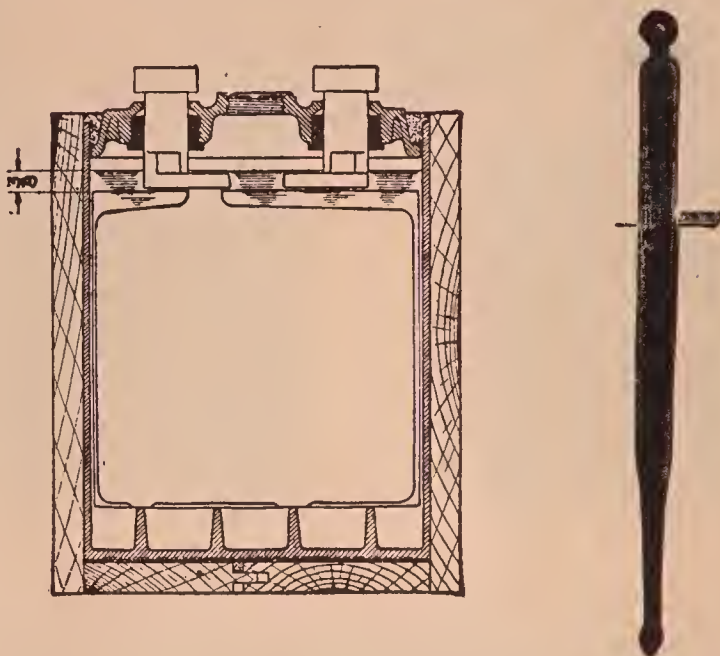


Fig. 55. Electrolyte Level and Thermometer

Left—Correct level of electrolyte: $\frac{3}{8}$ " (10 mm.). Right—Dairy thermometer.

Do Not Add Anti-Freeze or Other Compounds to Electrolyte—Under no circumstances should denatured alcohol, kerosene, or other anti-freeze compounds, or any other substance be used in the electrolyte with a view to preventing freezing, for such compounds are exceedingly harmful. The only safe way to prevent a battery from freezing is to keep it at all times fully charged.

Battery recharging solutions sold under various trade-names at high prices are generally nothing more than ordinary electrolytes of about 1.245 specific gravity and are entirely useless. In addition to this, some of these solutions contain such substances as sodium sulphate, nitric acid, etc., and their addition to a battery will very greatly shorten its life.

Keep the Battery Dry—The storage battery and the compartment it is in should be kept clean and dry at all times. The top of the storage battery is always more or less moist, and if this moisture is not occasionally wiped off it may soak into the battery case to such an extent that a short-circuit will occur.

Corrosion—The most common effect of neglect in this respect is the formation of a yellowish-white substance (iron sulphate) around the battery handles and iron parts in general, and a greenish or a whitish salt (copper or lead sulphate, respectively) around the terminals. These salts should be wiped off as soon as they appear and the parts affected thoroughly washed with a dilute ammonia solution or one of common baking soda (sodium bicarbonate) and water, and, when dry, coated with vaseline.

Cleanliness—Failure to keep the battery itself and the battery compartment in a perfect state of cleanliness and as dry as possible will result in extensive corrosion of the battery parts and of those parts of the car adjacent to it. If this corrosion becomes excessive, it is best to drive the car to a battery repair shop and have the battery and its compartment painted with an acid-proof paint.



Fig. 56. Result of Overfilling Battery

Overheating—One of the most prolific causes of battery ills is overheating and results in buckled or warped plates, which cut through the insulators and in most cases injure the battery. There are several causes for overheating; any of or all these may be avoided if the battery is given proper attention.

The most common cause is failure to keep the battery filled with distilled water, so that the plates and insulators are completely covered with electrolyte.

Overheating results from continued undercharging, also. When plates remain in this condition, they harden and hence offer such resistance to the charging current that the temperature of the battery rises. This condition usually results from the inexperience or carelessness of the driver, lack of judgment in use of the lights, or operation of the starter oftener than is necessary.

On the other hand, overheating may result from overcharging. If the engine is used for a protracted period, that is, if long trips are made in which the starter and lamps are used but seldom, or not at all, the driver should stop occasionally to feel the terminals of the battery; if they are sensibly hot to the touch, all the lights should be immediately turned on and the journey finished in this manner. In taking battery temperature, a careful owner will secure a dairy thermometer and during very hot weather or on long trips will, from time to time, take the temperature of the electrolyte; if necessary, he will add water (distilled) to the electrolyte during the journey.

Temperature Danger Point—Under no circumstances should the temperature of the battery be allowed to exceed 110° F. (43.3° C.), as serious injury will result. **ADJUST THE GENERATOR TO MEET DRIVING REQUIREMENTS.**



Fig. 57. Damaged Battery Plates

Left—Overheated battery plates, caused by sulphation. **Center**—Buckled battery plates. **Right**—Showing effect of lack of distilled water.

The work a battery is called upon to do varies with the driving requirements of the individual car owner. A city physician who has many short runs during the day with frequent starts and stops and a commercial traveller or tourist who travels at a relatively high speed on long uninterrupted trips demand radically different sorts of service from their batteries. As a general proposition, the charging output of the generator is regulated to meet most driving conditions, but should the car owner notice that due to some peculiar requirements he has to meet in his driving the battery temperature tends to rise beyond a safe figure, it is advisable for him as quickly as possible to consult a competent battery shop and have the charging rate of his generator reduced to a point that minimizes the heating.

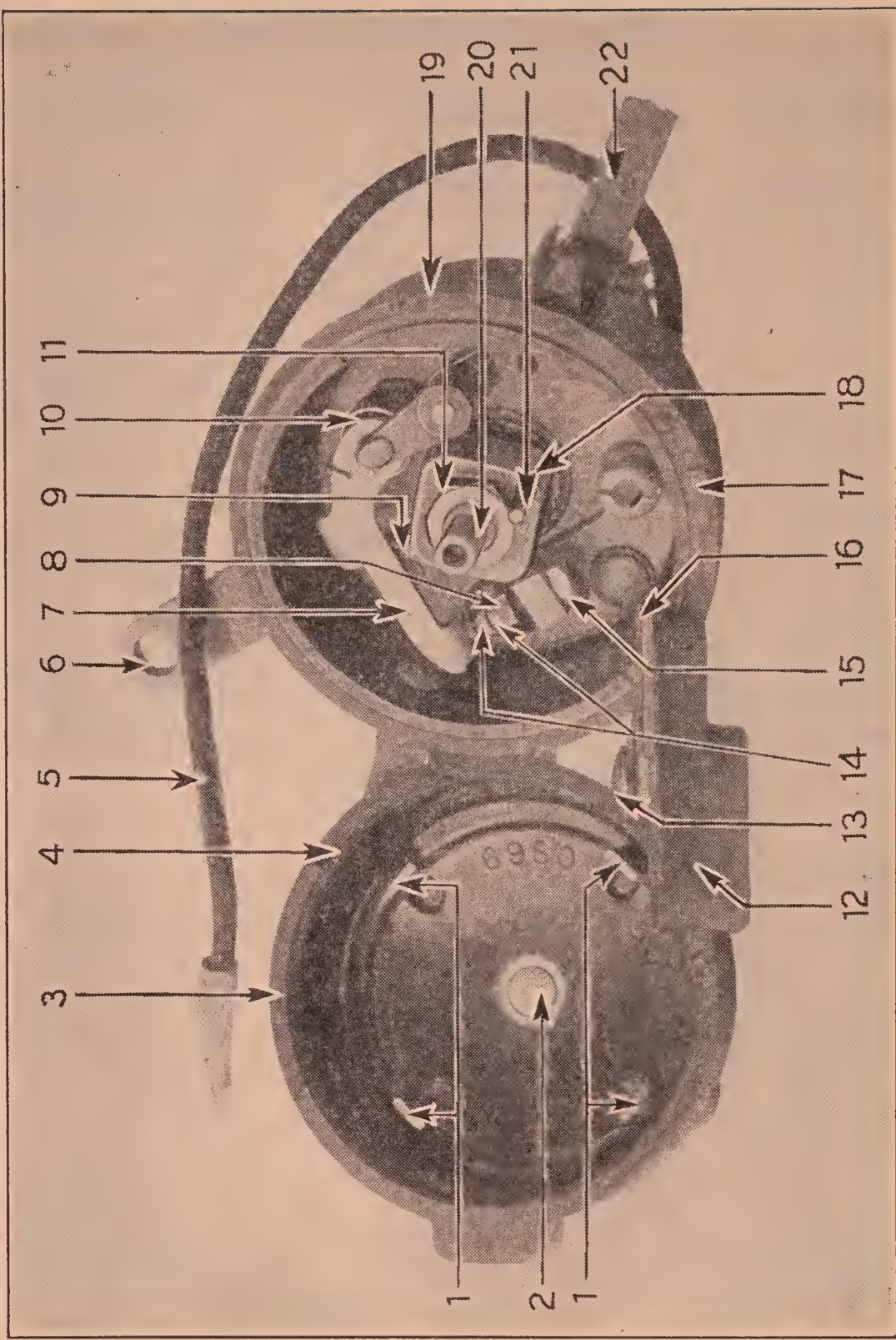
Improper Functioning of the Battery—In the following list of causes of improper functioning of a storage battery, most contingencies have been covered. Lest the car owner, however, be appalled at so lengthy a list of possible battery failures, he will do well to bear in mind that none of them arises from inherent defects either in the battery itself or in the starting and lighting system; all, or nearly all, these faults result from abuse or neglect or from improper conception of what use of a battery entails. In short, proper use and care will eliminate them all.

SYMPTOMS	CAUSES	REMEDIES
Battery slowly loses its charge	Slight short-circuit or ground in external wiring; insulation on wires oil soaked	Examine and repair all wiring
	Deteriorating wood separators(insulators) in battery	Install new wood separators
	Battery short-circuited by sediment accumulation	Clean out sediment
Battery suddenly ceases to function	Short-circuit in external wiring	Examine and repair all wiring; reinsulate
	Wood separators punctured by buckled plates	New plates may be necessary
	Foreign substance may have entered battery	Repairs depend on character of impurities
Battery weak in cold weather	Battery frozen	Very difficult to repair; try a long charge at a low rate
	Battery discharged	Recharge
Specific gravity does not come up on charge	Plates sulphated; active material crystallized	Try long charge at one-half the finish rate
	Lack of electrolyte; electrolyte spilled or otherwise lost	Have specific gravity balanced (adjusted) by a good battery man
	Presence of impurities	Take battery to battery repair shop
Specific gravity low; no strength; starter will not crank engine	Battery uncharged	Charge from external source; use lights and starter sparingly
	Generator not functioning	Have generator regulated by expert
Continuous low specific gravity; low level of electrolyte in one cell	Wood separators starting to deteriorate	Have battery reinsulated
	Cracked or broken jar or cover	Have broken jar or cover replaced
Overheated or buckled plates	Level of electrolyte low; generator out of adjustment	Fill with distilled water; regulate generator output or burn lamps

SYMPTOMS	CAUSES	REMEDIES
Broken down (deteriorated) wood separators	Adding acid instead of water; continuous charging at normal rate after battery is fully charged	Have specific gravity adjusted by competent battery man; burn lights while making long daylight runs
Lights not steady	Discharged battery; loose battery terminals; loose or dirty connections at switch, lamps or battery ground	Recharge; tighten terminals; examine all wiring
Starting motor does not crank engine	Battery discharged Corroded or loose battery terminals Loose connections in starting switch Starting motor out of adjustment Broken wire Starting pinion jammed	Recharge Inspect, clean, tighten, and grease terminals Inspect switch Inspect brushes and commutator Inspect wiring See page 133
Generator does not charge	Worn generator brushes Open-circuit (broken or disconnected wire)	Adjust, or replace if necessary Secure the services of a reliable electrical repair man Inspect all wiring connections
Generator charges at too high or too low a rate	Generator out of adjustment	Have generator adjusted by expert (see chapter XIV, part three)
Electrolyte boils out of battery vents; battery hangers corroded Battery handles badly corroded	Overfilling Generator out of adjustment Cracked battery cover Leaky sealing of battery cover	See instructions on proper filling Regulate generator Replace cover Have battery resealed
Electrolyte leaks out around posts	Hole in battery vent plug clogged Leaky post sealing Overfilling Battery loose in hangers; clamps loose	Remove obstruction in vent Have post resealed See instructions on filling Tighten clamps; have battery repaired

SYMPTOMS	CAUSES	REMEDIES
Battery terminals corroded	Leaky terminal posts; sloppy filling	Clean all external parts with a solution of ammonia or baking soda and water
	Lead plating on terminals worn out	Clean terminals and cover with insulating tape; apply heavy coating of vaseline or similar material
Metal battery hangers badly corroded	Leaky battery jar or cover	Replace defective part
	Sloppy filling; boiling due to overfilling or excessive charging	Clean hangers and paint with acid-proof paint

Practically all cases of improper functioning can be averted by three things: Cleanliness of the battery and its compartment; tightness of the battery cable connections; and frequent and regular addition of pure water to the cells requiring it.



- 1 Distributor cap terminal extensions
- 2 Distributor cap center terminal
- 3 Distributor cap
- 4 Distributor cap locating-slot
- 5 Wire, ignition coil to ignition breaker
- 6 Spark advance lever
- 7 Breaker arm
- 8 Breaker adjusting-screw
- 9 Fibre rubbing block
- 10 Breaker arm spring
- 11 Breaker cam lock-nut
- 12 Distributor rotor arm
- 13 Rotor arm center contact
- 14 Breaker points
- 15 Breaker adjusting-screw lock-nut
- 16 Rotor arm contact-segment
- 17 Distributor cap locating-pin
- 18 Breaker cam
- 19 Breaker housing
- 20 Distributor shaft
- 21 Rotor arm driving-pin
- 22 Distributor cap clip

Fig. 58. Ignition Distributor

CHAPTER XVI

THE IGNITION SYSTEM

Care of the Ignition Distributor Breaker Points—Frequently inspect the ignition distributor breaker points and clean them whenever their condition warrants it. Points in good condition have a frosted appearance and are a uniform grey in color. Badly pitted points should be replaced with new ones.

The breaker points should open 0.025" to 0.030" (0.64 to 0.76 mm.). Use the gauge attached to the distributor wrench to determine the correct opening.

The breaker points must be kept absolutely clean and completely free from grease and oil at all times; they should make even contact with one another over their entire surfaces. Should they spark excessively when the engine is running, or appear dirty or burned, clean and dress them, using a fine, flat Swiss or jeweler's file. Insert the file between the breaker points and draw it straight out; repeat this operation until the points are **square**, with even surfaces. Do not move the file back and forth between the points, as this will round off their edges and will result in a convex rather than a flat surface. Do such work carefully, directing every effort toward securing absolutely square surfaces. It will then be necessary to adjust the points to open the correct amount; it is advisable at this time also to check the correctness of the ignition timing.

It may be necessary to adjust the breaker points once or twice during the first 2,000 miles (4,000 km.) of driving; thereafter practically no attention is necessary other than occasionally to note whether their adjustment is correct and that they are clean and free from burns, etc.

To Adjust the Breaker Points—Loosen the breaker adjusting-screw lock-nut (15, fig. 58) and turn the adjusting-screw (8, fig. 58) inward or outward so as to provide a gap of 0.025" to 0.030" (0.64 to 0.76 mm.); use the gauge attached to the distributor wrench to determine the right gap.

Too large a gap will cause the engine to run badly—misfiring will probably result; too small a gap has the effect of retarding the spark and will also result in a poor running engine.

Timing the Ignition—The ignition is timed as follows:

1. Remove the spark plugs. Crank the engine by hand until No. 1 inlet valve (the second valve from the front of the cylinder head) has opened and closed. Insert a screwdriver or similar tool through No. 1 spark plug hole into the cylinder (see fig. 9). Continue to crank the engine by hand until no further upward movement of the piston can be felt with the screwdriver; this point is the upper dead center of the compression stroke. Remove the starting crank to prevent further movement of the pistons.

2. Adjust the breaker points so as to open 0.025" to 0.030" (0.64 to 0.76 mm.).
3. Move the spark hand lever to the retard position.
4. Remove the cam lock-nut (11, fig. 58) and, by means of the special wrench, loosen the cam from the end of the shaft (see fig. 59.)
5. Turn the cam until the driving-pin (21, fig. 58) assumes the position shown in fig. 59.
6. Continue to turn the cam in the direction of the arrow until the breaker points (14, fig. 58) **begin** to open, that is, the point at which the contact surfaces actually **begin** to separate.*
7. Securely hold the cam in this position and tighten the lock-nut.

In making the above adjustment, exercise every care against back-lash (looseness) between the distributor gears causing inaccurate timing. The ignition is correctly timed when turning the distributor forward (in the direction it rotates) ever so slightly causes the breaker points to separate, and turning it backward causes them to make contact with one another.

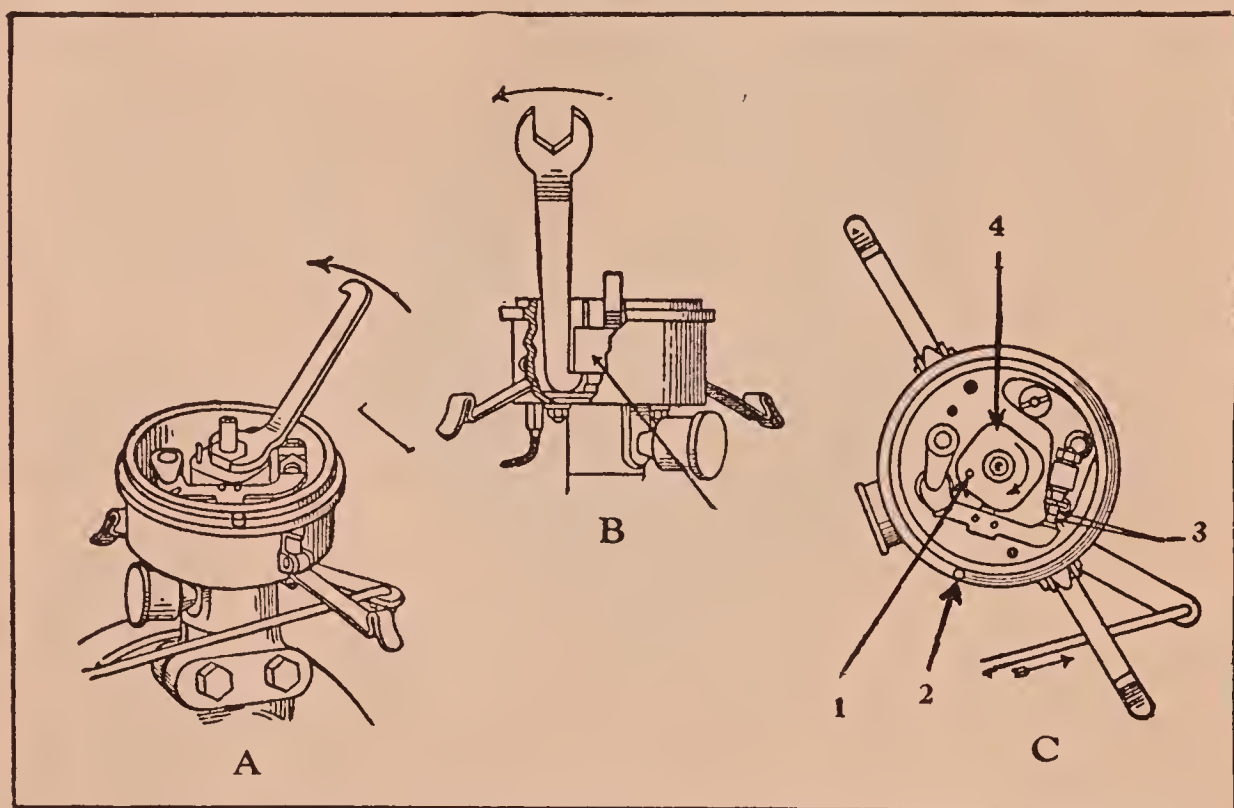


Fig. 59. Timing the Ignition, Distributor System

1 Cam driving-pin 2 Distributor cap locating-pin 3 Breaker points 4 Cam
 A. Removing the cam lock-nut B. Loosening the cam C. Turning the cam to correct position

A piece of cigarette paper (or other very thin tissue paper) can be used to determine exactly when the breaker points separate. Insert the paper between the points and attempt to draw it from between them, turning the rotor forward the while. When the breaker points are accurately adjusted—and the ignition therefore correctly timed, it should be possible, at that point at which the rotor can be turned no farther in the direction in which it rotates, to draw the paper from between the points without tearing it.

*In this position, the contact-segment (16, fig. 58) in the outer end of the rotor-arm should be closest to the terminal-extension (1, fig. 58) of No. 1 spark plug cable, when the rotor-arm and distributor cap are replaced.

Firing Order—The firing order of the cylinders (the sequence in which ignition occurs) is 1-2-4-3. It is necessary, therefore, in connecting the spark plug cables to the terminals on the distributor, that they be so arranged that this sequence is retained. No. 1 distributor terminal is connected to No. 1 spark plug, and the next one (in the direction the rotor turns) to No. 2 spark plug. No. 3 terminal, however, is connected to No. 4 spark plug, whilst No. 4 is connected to No. 3 spark plug.

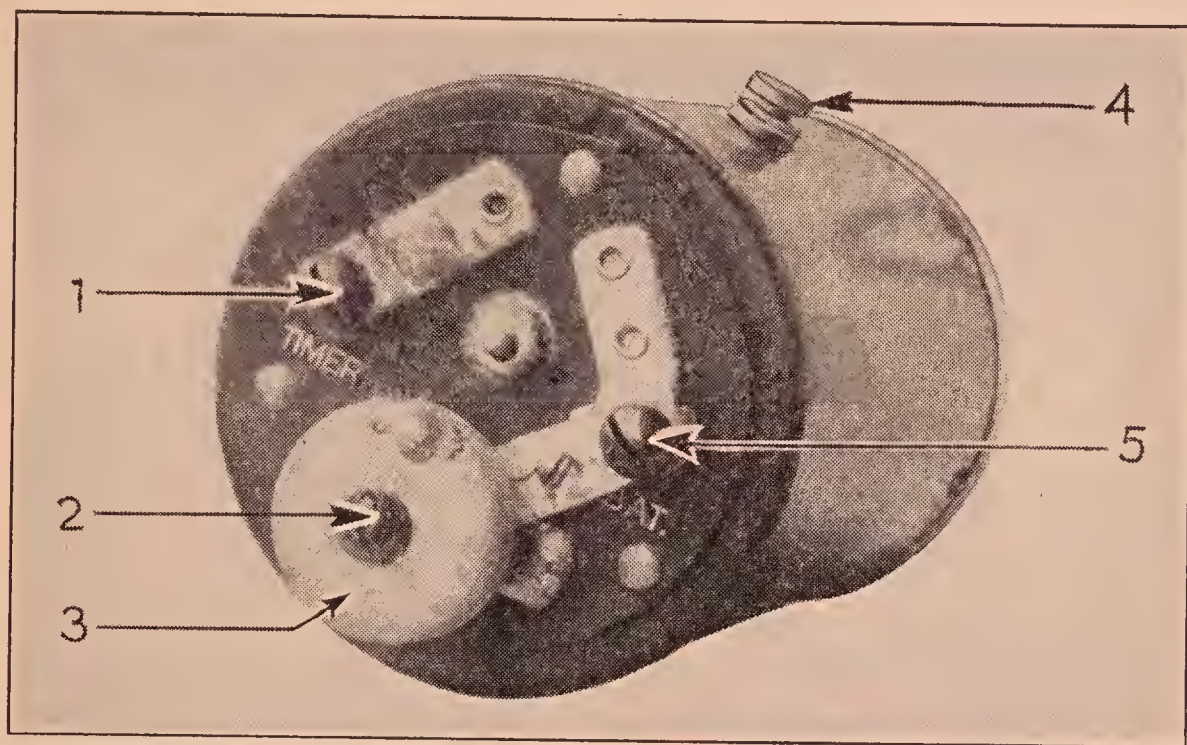


Fig. 60. Ignition Coil.

- | | |
|---|--|
| 1 Terminal, ignition coil to ignition
breaker wire | 4 Terminal, ignition coil to ignition
distributor cable |
| 2 Resistance unit center-screw | 5 Terminal, ignition switch to ignition
coil wire |
| 3 Resistance unit | |

Resistance Coil—In order to prevent too much current flowing through the ignition coil and to protect it from injury arising from leaving the ignition switch turned on with the engine not running, a resistance unit (3, fig. 60) is fitted. Since this part is connected in series with the battery, that is, the current flowing from the battery or generator must pass through it before entering the ignition coil, it automatically holds the voltage at the right figure and thus makes possible at all times a uniform spark at the spark plugs.

In the event of the ignition system not functioning properly, it is advisable to examine the resistance unit before looking elsewhere for the fault, as the resistance wire may have burned out—broken, due to too much current. Should this prove to be the case, a temporary repair can be made by disconnecting the wire from 5, fig. 60, and connecting it to 2, fig. 60.

Replace the resistance unit with a new one at the earliest opportunity, and **USE EVERY CARE THAT THE IGNITION IS NOT LEFT TURNED**

ON WHEN THE ENGINE IS NOT RUNNING, or the ignition coil will be burned out—rendered useless.

To Test the Ignition Coil—Remove the distributor cap. Crank the engine by hand until the breaker points close—are in contact with each other. Turn the ignition switch to the ON position.

Hold one end (bare metal) of a piece of copper wire on the ignition coil terminal marked BATTERY (5, fig. 60) and brush the other end (also bare metal) against some metal part of the engine. If no spark or flash results, a loose connection or a broken, disconnected, or short-circuited wire is indicated between the battery and the ignition switch or between the latter and the ignition coil; or the ignition switch may be at fault or the battery discharged.

If a spark or a flash results, test for ignition spark by holding one end (bare metal) against the metal base of the ignition coil* and the other end within $\frac{1}{8}$ " (3.0 mm.) of the ignition coil high tension terminal (4, fig. 60).

With the ignition switch still in the on position, quickly open the breaker points—that is, separate them. If the ignition coil is in good condition, a spark will jump across the gap thus formed. If no spark is obtained, the coil is not grounded—its metal base is not making good contact with the generator—or it has been damaged.

It is inadvisable to attempt ignition coil repairs except in properly equipped and qualified shops.

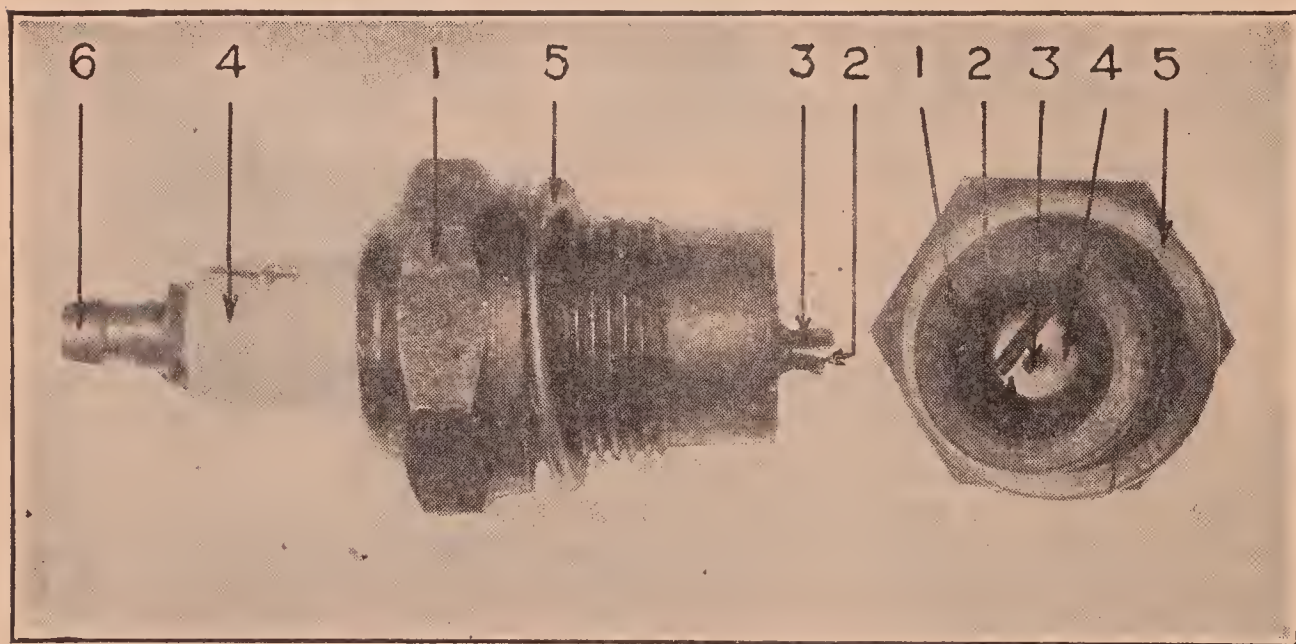


Fig. 61. Spark Plugs

- | | |
|--------------------|--------------------------|
| 1 Spark plug shell | 4 Porcelain core |
| 2 Spark plug gap | 5 Copper-asbestos gasket |
| 3 Center electrode | 6 Spark plug terminal |

Spark Plugs—Pay particular attention to the condition of the spark plugs and their gaps. The spark plugs, both inside and outside, should at all times be kept free from accumulations of oil and carbon. Water, likewise, should

*In making this test, use a piece of insulated wire or a shock will result.

be prevented from reaching the porcelain or mica core, as its presence there provides a path for the current, which would then flow from the spark plug terminal to the spark plug shell without passing through the central electrode, thus causing the plug to misfire.

Spark Plug Gaps—The spark plug gaps should be adjusted to provide an opening of about the thickness of the gauge attached to the distributor wrench, although this amount can be slightly varied with advantage to meet the needs of the individual engine; approximately 0.030" (0.76 mm.), is the right figure. If the gaps are too large, it is quite probable that difficulty will be experienced in starting the engine; misfiring almost certainly will result, particularly on a hard pull, and the general operation of the engine will be poor.

It should always be remembered that although a spark can jump a spark plug gap when the plug is removed from the cylinder it does not necessarily follow that it will do likewise in the cylinders. The reason for this is that the compressed gas within the cylinders offers a much higher resistance to the passage of the current than is encountered in the open air.

Spark Plug Defects—If the core of a spark plug is cracked or broken, or if the spark plug points are covered with oil, or should the inner part of the core be covered with a deposit of carbon, the plug will not fire (a spark will not jump across the gap). In any of these cases, with the exception of that of a cracked or broken core, the plug should be thoroughly washed with gasoline and a stiff brush, the points adjusted to the proper gap, and then replaced in the cylinder.

A cracked spark plug core is very difficult to detect. The quickest way of determining if the core is at fault is to remove the plug in question and substitute a new one; if the condition is remedied in this manner, the cracked or broken core should be replaced with a new one or a new plug substituted.

Starting a Stubborn Engine—Should great difficulty be experienced in starting the engine and after all other remedies have been tried and have failed, the desired result can sometimes be obtained by towing the car or coasting down a long and quite steep hill.

To prevent grinding of the gears when either of these expedients is resorted to, shift into high gear before the car is set in motion, but keep the clutch disengaged. When the car has reached a speed of 15 to 20 miles (25 to 30 km.) an hour, gently engage the clutch; if the engine is cold, manipulate the carburetor choke in the usual manner. **Do not forget to turn on the ignition switch.**

As the car is now travelling at the rate of 15 to 20 miles an hour and the clutch is engaged on high gear, the engine will be turning over at a comparatively high rate of speed; unless some adjustment is radically wrong, the engine will start.

Caution—If the car is being towed, be careful to use as long a tow rope as is practical, to prevent running into the car ahead when the engine starts;

and, needless to say, when coasting down a hill is resorted to, some means should be provided for having the car brought back to the garage should the engine still fail to start.

Engine Fails to Start—If the engine fails to start and it is believed the ignition is at fault, proceed as follows:

1. **Make certain the ignition switch is on.**
2. Turn on the head-lamps and note whether their light is dimmed when the starting motor is used. If so, test the storage battery to determine if it needs charging. Possibly the battery terminals are loose or corroded; or there may be a loose connection in the wiring at some point between the battery and the ignition switch or ignition distributor. If the battery is in a discharged condition, it may still be possible to start the engine by hand-cranking, or by towing or coasting
3. Remove a spark plug cable from a spark plug and hold its terminal $\frac{3}{16}$ " (4.7 mm.) away from some metal part of the engine whilst the latter is being cranked by means of the starting motor. The spark should readily jump across the gap thus formed.

If no spark is obtained, test the ignition coil (see p. 154). If the coil is functioning properly, look for a disconnected, broken, or grounded high tension wire. Possibly the distributor rotor arm may be broken or missing, or the distributor cap may be cracked.

4. Examine the distributor rotor and breaker points. They should be clean and free from oil or grease. See that the breaker points are not burned, that they make even contact with one another, and that their gap is correct.
5. Examine the distributor head and rotor and the spark plug cables and other wires for cracked or broken insulation; possibly a wire is oil-soaked and its insulation hence defective.
6. Examine the spark plugs; they may be fouled with oil or short-circuited, their gaps may be too large or too small, or the porcelain cores may be cracked.

Engine Stops—First, ascertain if sufficient fuel is in the fuel tank and that it is reaching the carburetor, and then examine the ignition system, as described in **Engine Fails to Start**, above.

Engine Misfires Regularly—Regular misfiring in one or more cylinders is most probably caused by fouled spark plugs. To locate the plug, or plugs, at fault, throttle down the engine, with the spark retarded. Short-circuit the spark plug under test by placing a piece of metal, such as a screwdriver, between the spark plug terminal and some metal part of the engine; be careful to hold the screwdriver by its wooden handle or a shock will result. If short-circuiting the plug under test produces no appreciable change in the engine's speed, the plug is not firing; if it causes the engine to run more slowly or stop, or to run irregularly, the plug under test is firing properly. If the spark plugs

are all in good condition and the misfiring continues, it may be due to some other cause, such as a broken spark plug cable, a loose or disconnected wire or cable, a stuck valve, etc.

Engine Misfires Irregularly—Irregular misfiring may be caused by dirt or water in the carburetor, or by air leaks, sticky valves, etc. If the ignition is at fault, look to the following:

1. Dirty, burned, or improperly adjusted breaker points.
2. Loose connections in the battery circuit. Examine the connections at the back of the ignition switch and the ammeter, and at the distributor, reverse current cut-out, and generator. The battery terminals may be loose or corroded, or the battery ground connection may not be tight.
3. A wire may be short-circuited. Examine the spark plug cables and the cable running from the distributor to the ignition coil.
4. The spark plug cable connections may be loose.
5. The spark plugs may be dirty, or their gaps too large or too small.

Under no circumstances should the engine be run whilst the battery is out of the car, or disconnected from the generator, without first having grounded or short-circuited the generator (see p. 134).

Three things are prerequisite to efficient ignition: One, absolute cleanliness of the distributor and the breaker points; two, absolute tightness of all wire connections; three, correct adjustment of the breaker and the spark plug gaps. These three conditions fully met, perfect ignition will result.

If you are not absolutely certain of your ground, it is best in making adjustments or repairs of ignition apparatus to avail yourself of the services of a competent mechanic. Ignition adjustments and repairs are not difficult nor are they involved, but a slight inaccuracy will cause results entirely out of proportion to the degree of error.

CHAPTER XVII

THE TYRES

In all probability, most of the so-called tyre troubles result from misuse. Tyres receive much less attention than they should and short life is the inevitable result.

Non-Skid Chains—Non-skid chains that are improperly adjusted or fastened to the spokes of the wheels in such a manner that the chains can not move result in injury to the treads of the casings.* In most cases the treads are cut through to the fabric (the canvas carcass of the casing) and are loosened and badly worn. When chains are applied loosely enough to work around the casings, the resulting wear is evenly distributed over the entire tread.

Do not use non-skid chains oftener than is absolutely necessary.

Cuts—The neglect of small cuts in the tread of a casing is productive of rapid deterioration. When such cuts are not promptly repaired, water works its way into the canvas carcass and rot soon develops. In addition to this, sand enters and gradually is forced between the tread and the carcass. This condition, known as sand boils, produces prominent lumps or protuberances on the tread. The result is a tread loosened from the carcass and an untimely end to the casing's usefulness.

It is unnecessary to remove the tyre to repair small cuts of this nature. Most tyre companies sell a compound for filling small cuts, the use of which will prevent moisture and sand from working their way into the fabric. The car owner is strongly advised to purchase such repair materials and make use of them, thus adding miles to the life of his tyres.

Misaligned Front Wheels—This condition generally affects both tyres equally, although sometimes but one is injured. As has already been remarked in chapter VII, part three, improper adjustment of the steering knuckle tie-rod or a bent steering knuckle arm is responsible for misalignment. The preventive is periodical inspection and adjustment whenever necessary.

Wear Caused by Brakes—Locking of the wheels, caused by sudden application of the full braking effort and particularly from unequalized brakes, causes very rapid wear of the rear tyres. When the brakes are applied in this manner, one or more of the wheels is prevented from rotating and therefore slides over the road surface. This results in the tread and part of the canvas of the casing being badly worn or scraped off at a number of points. Correct adjustment and use of the brakes will prevent this condition.

Evils of Under-Inflation—One of the greatest evils in connection with the use of pneumatic tyres is that of under-inflation. Since a tyre depends on the pressure of the air within it to maintain its shape, it follows that too low a pressure will cause the tyre to flatten in a proportionate degree when

* A casing is the outer part of a tyre; the tube; the tyre's inner part.

carrying a load. Such a condition results in the canvas throughout the casing being alternately bent and straightened and ultimately causes a continuous break in the side wall of the casing.

Correct Tyre Inflation—Inflate tyres to the following pressures.

	Cord		Fabric	
	Lb.	Kg.	Lb.	Kg.
Roadster	40	2.75	50	3.5
Touring	50	3.5	60	4.25
Coupe	45	3.25	55	4.0
Sedan	60	4.25	65	4.5

The above pressures are based on the weight of the car and occupants; if this is materially increased, proportionately increase the inflation pressure.

Frequent and periodical testing with a tyre pressure gauge, followed by immediate inflation if necessary, will add miles to the life of the tyres. If the pressure falls 10 per cent. or more below the above figures, inflate the tyres.

Regardless of what you may be told by well-intentioned but misinformed persons, tyre pressure in hot weather is practically unincreased by heat. Under such conditions it may rise 10 per cent.—but no more—and the tyres should therefore not be partly deflated, as is often the practice.

Suggestions—All tyres are constructed to carry a certain maximum weight, the total weight of the car and its passengers being distributed among the four tyres of the car. Overloading the car beyond the maximum carrying capacity of the tyres will have its effect in shortening their life.

Do not turn corners nor run over sharp obstructions such as railroad tracks at a high rate of speed. Running over large, sharp stones in the road is likewise bad practice. The fabric—canvas carcass—of a casing is very easily damaged or entirely broken through in this manner, resulting in a more or less large hole through which the inner tube blows out.

Scraping against curbs or running in railroad tracks or ruts has a damaging effect on the side walls of the casings. This treatment wears off the thin coating of rubber at this, the weakest point and exposes the fabric to the entrance of moisture, thus soon causing rot.

If a tyre continues to lose pressure after frequent inflations, examine the valve, as it may be leaking. Turn the wheel so that the valve is uppermost, remove the valve cap, and test the valve for leakage by immersing it in a glass of water. The core, or inside, of the valve, which can be screwed in or out by means of the slotted head of the valve cap, may be at fault and should be replaced with a new one. If the leaking persists, replace the tube with another and immediately repair the defective one.

If a tyre should be punctured, immediately stop the car and repair or replace the damaged tube. At the same time examine the casing both inside and outside for a nail or a piece of glass. Running even 100 yards (100 m.) on a punctured tyre may ruin both the casing and tube.

Never place a tube in a casing that has been punctured until the cause of the puncture has been found and removed.

Do not store spare inner tubes with tools unless protected against the injury that is bound to result. Encasing the tubes in bags—especially made for this purpose and readily procurable from most dealers—is the best practice to follow; the tubes should be cleaned and well dusted with tyre talc before placing in a bag.

Tubes are stored by folding them into a compact package (see fig. 62). Remove the valve core by unscrewing it with the slotted end of the valve cap, to allow the air to escape. Twist the tube so that the valve projects outward and roll up the tube. Hold the tube in this position and replace the valve core and cap, fold it into a package, and securely bind it with a cord or an elastic band.

Oil and grease are highly destructive to rubber. The garage floor should at all times be kept clean. If the tyres come in contact with such matter, wash them off with gasoline as soon as possible.

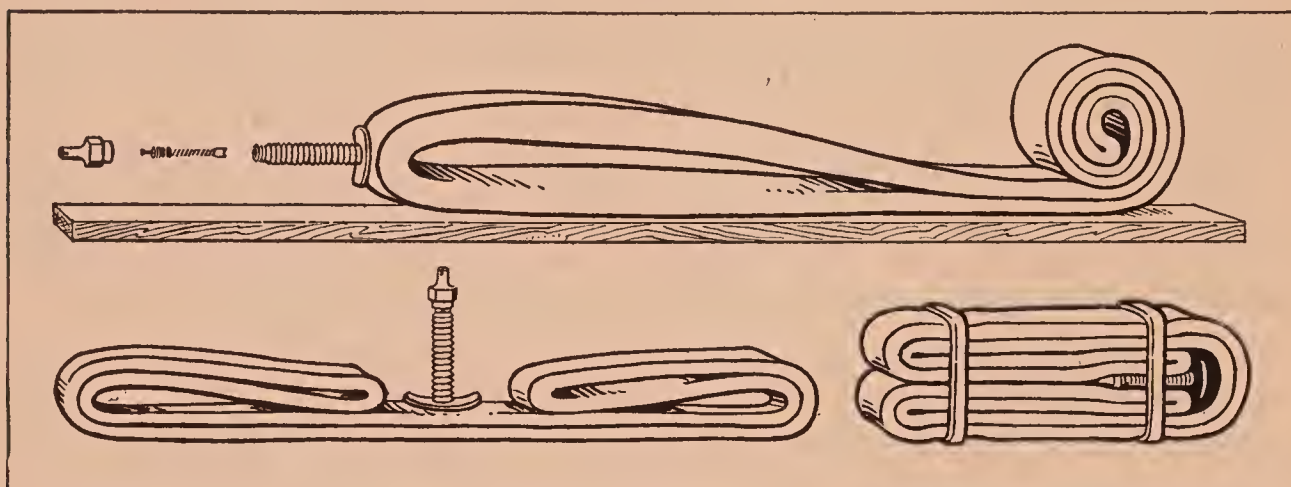


Fig. 62. Folding an Inner Tube

If the car is not in use in winter, the tyres should be removed from the rims, partly deflated, and stored away in a cool, dark, dry place. In this regard, it should be borne in mind that strong light has a deteriorating effect on rubber and should be avoided whenever possible.

Do not under any circumstances store the car away with the tyres mounted unless it is jacked up to relieve them of its weight.

CHAPTER XVIII

RIMS AND WHEELS

Care of the Rims—Keep the rims clean and free from rust at all times; the use of a tyre flap or liner between the rim and the inner tube is advisable. Should rust appear, remove it with sand or emery cloth and paint the rim with shellac or a good graphite (black lead) paint; there are a number of preparations to be had for this purpose.

A little oil or grease applied to the nuts, bolts, and wedges is of value in preventing rust and will facilitate changing a rim.

Creaking Spokes or Wheels—Creaking spokes or wheels (wood) result from unequally tightened demountable rim wedges or loose spokes, the latter caused by the wheel being excessively dry or abuse. Loosened spokes can sometimes be temporarily repaired by soaking with water, but it is always best to have a wheelright attend to them.

CHAPTER XIX

THE BODY WORK AND CAR EQUIPMENT

Wash the Car—It is best at all times to wash the car before mud has had a chance to dry on the highly finished surfaces, because mud while still soft is most easily removed; if allowed to dry on a varnished surface, mud mars the finish.

If running water is available for washing, a hose should be used, but in this case the full pressure of the water should not be permitted to strike the surfaces being cleaned. High water-pressure has a tendency to drive the hard particles of sand and the like into the varnish. Do not use hot water as this, too, is injurious. Flow the water on with a hose (from a bucket, if a hose is not available) until all the mud has been removed, when the surfaces should be gone over with a carriage sponge continuously saturated with water. Grease or road oil can be washed off with a sponge and soap and water, but avoid strong rubbing as much as possible. (See chapter III, part one, for soap specifications.) Avoid as much as possible the use of soap on the body and bonnet; use it sparingly on the mud guards, running gear, etc., also.

It is highly desirable that soap, as such, be prevented from coming into direct contact with the varnished or enameled surfaces of the car. **Use a soap solution**—one to two pounds of soap to each gallon (0.5 to 1 kg to every 4 litres) of water, heating the water until the soap is completely dissolved. In washing the wheels, mud-guards, etc., of the car, add one quart (one litre) of this strong soap solution to each pail of water. Do not use even the soap solution on the body of the car; wash it only with clear water, flowed on.

At the conclusions of washing with soap and water, thoroughly rinse all the surfaces with fresh water, when the car should be wiped dry and polished with a clean chamois skin. Before using the chamois, soak it in cold water and wring it dry, repeating this from time to time during the drying process. Keep two chamois skins for this purpose, one for use only on the body work and upper side of the mud guards, and the other for use on the wheels and other parts of the running gear. After washing, the car should not be left standing in the bright sunlight, as it will dry too rapidly and streaking of the finish will result.

It is advisable to shower a new car with cold water and then to rub it dry with a clean chamois skin. This should be done before the car gets dirty, to set the varnish by hardening it with cold water and thus prevent the permanent lodging of dust in the still soft finish.

Care of the Top—Dust, dirt, mud, or grease should not be allowed to remain on the inside or the outside of the top (hood). From time to time the outside of the top should be cleaned with a dry, stiff brush, or, if convenient, it should be washed with pure soap and water and a sponge and then thoroughly rinsed. Gasoline, kerosene, or naphtha, or any other rubber solvent should

never be used, as the rubber in the fabric would be injured and the top permanently damaged; in all probability leaking would result. From time to time the inside of the top should be thoroughly brushed out and washed with pure soap and water, using a brush or a sponge for the purpose, and then rinsed with cold water. The side curtains and the top envelope should receive the same treatment.

Never put the top down when it is wet, for in addition to causing permanent wrinkles or creases, rotting or mildewing of the fabric is certain to result. This is true of the side curtains, also, and they, too, should be dry before storing away.

Do not brush the windows or lights in the side and rear curtains; they should be wiped with a soft cloth or sponge dampened with alcohol.

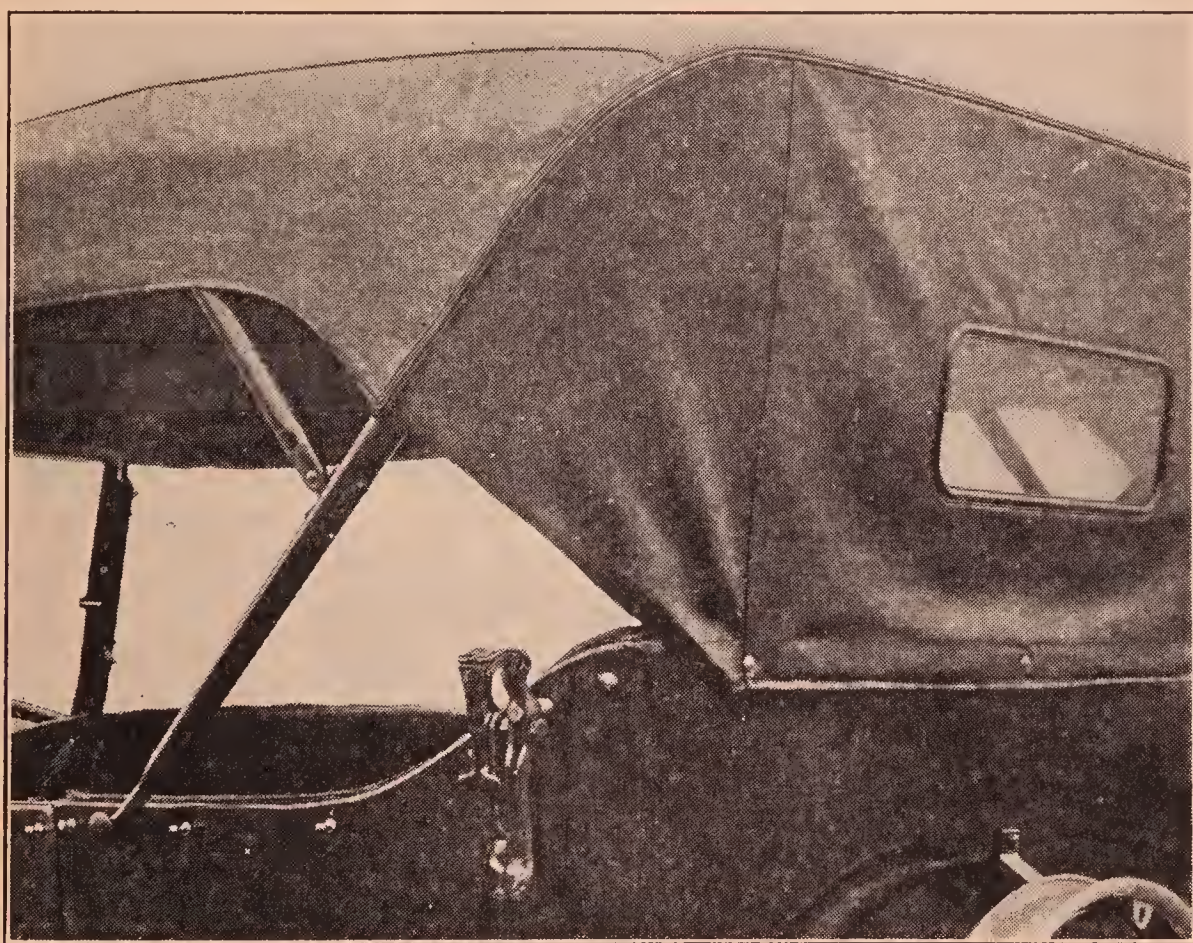


Fig. 63. First Step in Lowering the Top

Gypsy curtain folded inward

Especial care must be observed when folding—lowering—the top that the covering material is not damaged by improper handling. The accompanying figures illustrate the right method to follow. It is quite necessary that this method be adhered to, for if the top is folded in the usual manner, as in figure 67, the top covering material, which is then held fast between the top bows, will be cut through in a short time by chafing.

The first step in lowering the top is to unbutton the gypsy curtains (the

triangular curtains at the rear quarters of the top) and fold them inward, as shown in figure 63. Failure to do this will result in the curtains being torn when the top is lowered.

Next, open the top-holder bow-clamps and loosen the front end of the top from the windshield. The top is now ready to be lowered.

When the top bows are in the top-holders, pull the top covering material out and back, letting it fall as shown in figure 64, when the bow-clamps should be locked.

This done, fold over the corners of the top covering material in the manner illustrated in figure 65. Tightly roll up the top covering material and tuck it in between the upper- and lower-most bows, as in figure 66.

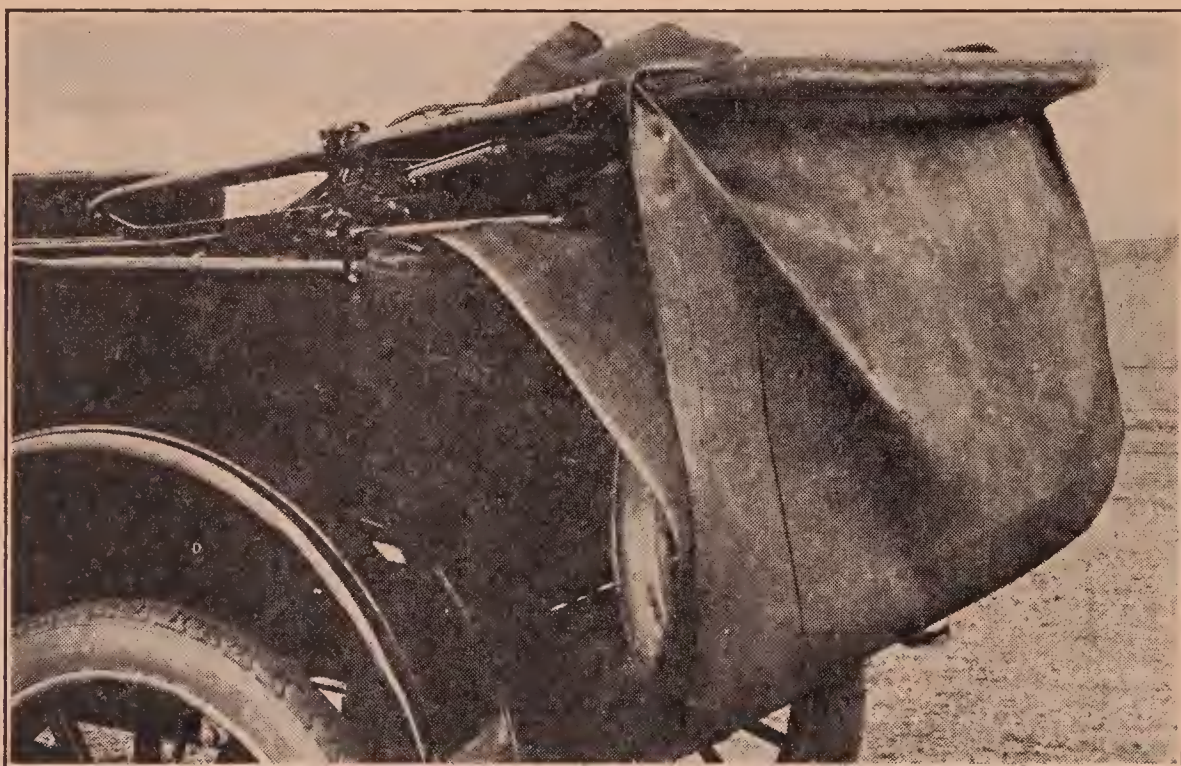


Fig. 64. Top Covering Material Pulled Out

The dust cover (dust envelope) should now be put on. Hold the top covering material in the position shown in figure 66 and slip the lower side of the dust cover under the bottom side of the lower bow, and then pull the upper side of it into position over the top side of the upper bow and button the fasteners.

It is important that two things be borne in mind in connection with the above operations: One, the top covering material must be completely pulled out from between the bows—the padded parts remain where they naturally fall; and two, the bows must be brought as close together as possible and then tightly clamped in this position.

Do not, under any circumstances, tuck the top covering material between the top bows as shown in figure 67.

Upholstery—From time to time the upholstery should be wiped off with a clean damp cloth. Frequent washing of the upholstery is also desirable. Use a pure soap and water and a sponge, finishing with a thorough rinsing with fresh cold water and wiping dry with a chamois skin; saddle soap, too, can be used to advantage.

Never use gasoline on the upholstering as it has a tendency to crack the leather or cause it to peel. If the leather becomes hard and dry, an application of neat's-foot oil or a mixture of equal parts of glycerine and sweet oil is beneficial. An application of this mixture should remain on the leather overnight and then rubbed dry to prevent soiling one's clothing; as an additional precaution, it might be well to wash the leather with soap and water, followed by rinsing with clean water to prevent this occurring.

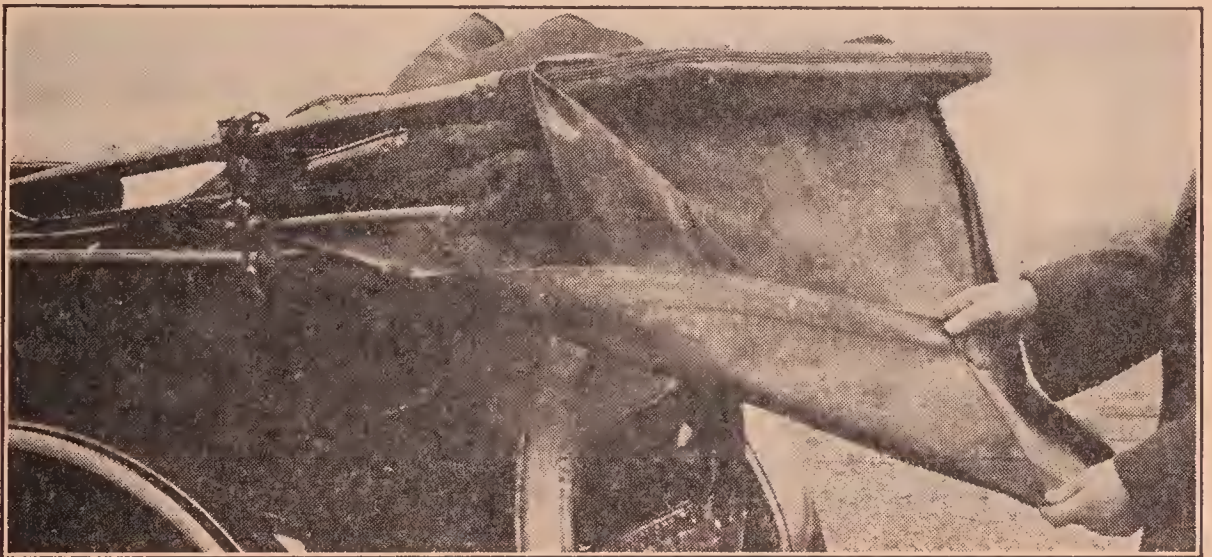


Fig. 65. Folding In the Corners

A vacuum cleaner is an excellent means of removing dust from the inside of the top and from upholstery.

Closed Car Upholstery—Closed car interiors are best cleaned by means of a vacuum cleaner. If this can not be done, the dust can be removed by brushing **downward** with a whisk-broom on the seat-backs and the sides of the body, and **toward the front** on the cushions and the head-lining. Brushing in this manner will keep the nap of the cloth in its original condition.

Ordinary spots can be removed by placing a damp cloth over the upholstery and running a hot iron over the entire surface. Do not steam a part of the surface, but go over the entire piece; and do not hold the hot iron at one place until the cloth dries, as this will leave a shiny spot.

Grease spots can be removed by means of ether, but it is necessary that the entire surface be gone over. Ether raises the nap of the cloth, which makes it necessary to steam the latter after the spots are removed.

Floor carpets can be cleaned by rubbing with a sponge or brush wet with gasoline.

Do not use soap and water in cleaning closed car upholstery, as the spots may be spread instead of removed.

Nickel Plating—Nickel plated surfaces can be protected against tarnishing or corrosion by frequent wiping with an oily cloth. A very high polish, however, can not be obtained in this manner; some form of metal polish must be used. Do not use brass polish on nickel plating, as it contains destructive abrasives.

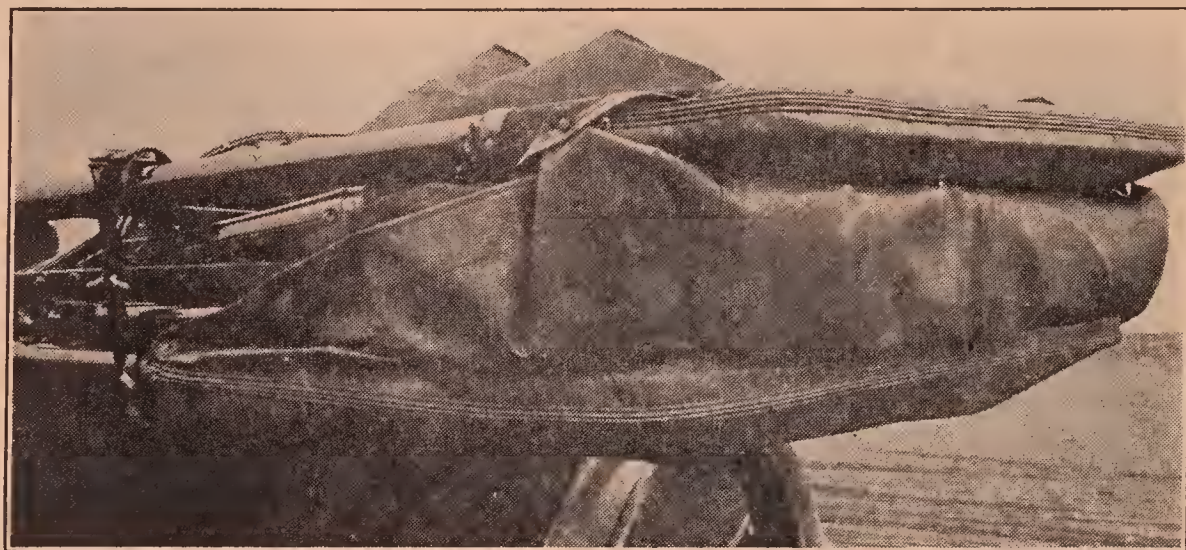


Fig. 66. Top Covering Material Rolled Up and Tucked Between the Upper and Lower Bows

Head-lamp Reflectors—When the head-lamp reflectors become dirty, do not wipe them, but use a stream of cold water to remove the dust and then let the reflectors dry. This treatment should be given the reflectors because they are silver plated and very highly polished; they are therefore extremely susceptible to scratching, even when a very soft material is used.

If the lamp reflectors become dull after long service, they should be polished with a very soft chamois skin and jeweler's rouge or crocus moistened with alcohol; place a wad of cotton within the chamois skin to form a ball about the size of an egg. The polishing should be finished with very fine crocus or rouge and chamois skin, but in this case it is applied dry. Polish with a circular motion, otherwise the reflector will be streaked. If the work is properly done, the results should be entirely satisfactory.

If the reflectors are in very bad condition and do not respond to polishing, have them refinished by a reliable metal plater.

Body Polish—As a general thing, avoid the use of any of the numerous preparations on the market for restoring the finish of the car. This is particularly true of the so-called body polishes or finish renovators (see chapter III, part one, for further remarks on this subject), which should at all times be avoided, regardless of what the accessory dealer has to say on the subject.

There are, however, certain preparations which can with benefit be applied to an old and worn top to restore its finish, as well as to make it waterproof.

Similar preparations for restoring the finish of the upholstery should be approached with caution, for although they frequently impart an excellent surface to the leather they also harden it to such an extent that cracking ultimately results. The best preparation to use for this purpose is a good, old-fashioned leather or harness dressing.

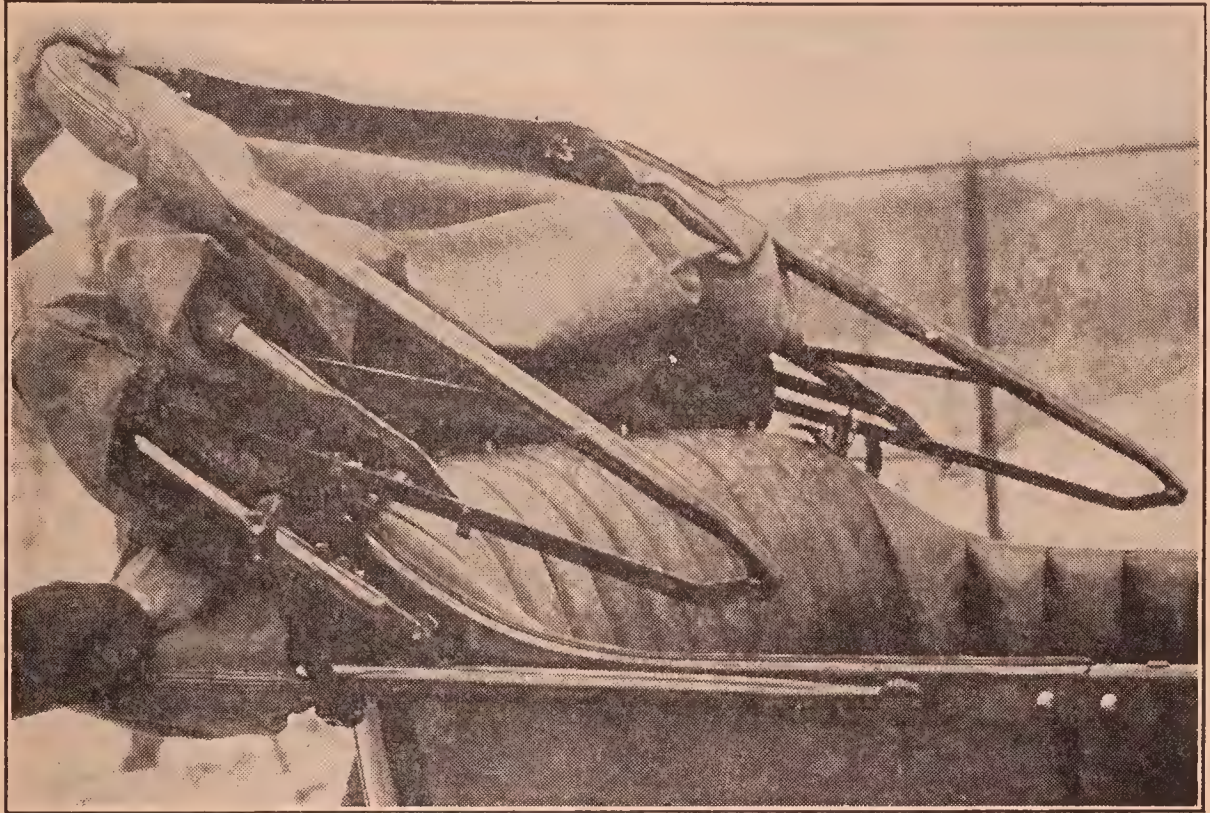


Fig. 67. The Wrong Way

Folding the top in this manner damages the covering material by chafing

CHAPTER XX

THE CAR IN WINTER OR DEAD STORAGE

Placing the Car in Storage—In taking the car out of service and storing it away for the winter or for any protracted period, many things require careful attention. Before proceeding further, however, it should be clearly remembered that a stable in which animals are kept and in which, therefore, ammonia is present, is most unsuitable as a storage place for a motor car; a damp or wet place, with little circulation of air, such as a cellar, is also to be avoided. A clean, dry, cool place, with free circulation of air and quite dark, constitutes an ideal storage room.

Unless the car is in a climate where freezing of water never occurs, the cooling system should be drained. Flushing at this time with a lye or washing soda solution and then with clean water to remove all traces of the lye or washing soda is desirable. When the cooling system is empty and with the drain cock still open, start the engine and let it run for a minute or two to ensure all water having left the cylinders. With the engine running, inject a syringe-ful of engine oil into the cold air inlet of the carburetor hot air hood, so that this oil will be drawn into the cylinders to all the working parts, and then immediately stop the engine. Drain the carburetor and vacuum tank and **securely replace the drain plugs.**

Remove the storage battery from the car and place it in the hands of a battery repair shop. (See chapter XV, part three, for further details.) If the engine is again run with the storage battery removed, **be sure to ground or to short-circuit the generator.** (See p. 134.)

Put up the top and attach the side-curtains. Jack up all four wheels and, if the tyres are not removed, slightly deflate them. It is best to remove the tyres from the rims and store them in a cool, dry, dark place, with the tubes slightly deflated.

Apply a coating of vaseline or similar material to the bright metal parts to protect them from corrosion. Put a cloth over the car to protect it from dust.

Putting the Car in Commission—In placing the car in commission, this process is reversed. The tyres should be inflated to the correct pressure, the side curtains stored away in the car, the bright metal parts cleaned, and the cooling, lubrication, and fuel systems filled; the storage battery, fully charged, should be replaced in the car and the battery cables connected to it.

Remove the spark plugs and, with an oil can or an oil syringe, inject one or two tablespoonfuls of clean, fresh engine oil into each cylinder. Replace the spark plugs and spark plug cables and crank the engine 10 or 15 seconds, either with the starter or the hand crank and with the ignition turned off, thus distributing the oil over the pistons and cylinder walls. The engine can then be started in the usual manner.

PART FOUR

WHAT GOOD ROADS MEAN
AND
GENERAL SPECIFICATIONS

CHAPTER I

WHAT GOOD ROADS MEAN TO THE MOTORIST

Of course, whilst the good motor car will travel over poor roads, and in the case of certain portions of some countries, over no roads at all, the cost of upkeep to the owner living in such districts is considerably higher than in territories noted for their well built and maintained roads.

After all, the motor car is a machine and no matter how sturdily constructed must eventually have its life curtailed and its working efficiency impaired by jolting over rocky passes or dragging through heavy sand. Not only do the various parts of the car need more frequent adjustment, and in some cases replacement, but also tyre mileage is greatly lowered and the number of miles to the gallon of fuel considerably reduced.

Furthermore, so long as the manufacturing of motor cars in quantities is restricted by the building of roads in the various countries of the world in which it is possible to sell cars, car prices must inevitably remain higher than when a greater market permits increased manufacturing.

But even apart from these points which most directly affect you as a motorist, the subject of better roads is of great indirect influence on the cost of living.

Almost every country in the world is now experiencing an era of high prices both as regards raw material and manufactured products; and, in the case of foodstuffs particularly, the large increase in cost must be borne by every family in these countries.

The business of farming is essentially dependent on the condition of country roads, for the bulk of the crops must be hauled to the railroad stations and local markets. Around each market or shipping point there is a boundary line which encloses the area that can be profitably cultivated for delivery at that point. If this area is considered as bounded by a circle, it is not difficult to see that its size will depend upon road conditions. The profit of the farmer is determined by the difference between production and transportation costs and selling price; production must cease when transportation costs wipe out this difference.

When the main roads of the great producing zones are improved, benefits will accrue not only to the producer but also to the consumer. Marketing will be distributed throughout the year and produce will not have to be kept at high storage rates in warehouses, due to inability to get it to market at certain seasons because of lack of transportation facilities. The farmer will thus be assured of equitable prices for his crops and will be encouraged to increase his production, which, in turn, will serve to bring living costs down to a normal level.

All this is becoming more and more evident to people generally and to

public authorities in the leading countries of the world, ranging from national governments and their centralized bureaus to county and township and municipal representatives. Enormous sums of money are being raised, to be spent during this and the next few years to give people the benefit of the economies that will result from the improvements of the world's highways.

The average citizen particularly is beginning to realize that the subject of better highways has a very definite relation to his cost of living. He is becoming aware that the small sums paid by him in taxes for road work are eventually returned manifold in decreased cost of farm produce and in lowering all transportation charges in which he has a distinct share. This is why he is urging appropriations for road improvement on his local and national legislative bodies and also the reason why he will continue to demand these appropriations until they are made.

And of all the proponents of better roads the motorist, of course, is the most vitally concerned. You will be well repaid for every effort you put forth to advance the cause of road building in your territory, whether it be in aiding to organize an influential good roads association in your locality or simply by voting to pass good roads legislation when the matter is presented to you. You are benefiting not only yourself but also every member of your community by doing everything in your power to increase the transportation facilities of your country.

CHAPTER II

SPECIFICATIONS

BORE AND STROKE.....	3 11-16" x 4" (93.8 mm. x 101)
PISTON DISPLACEMENT.....	170.9 cu. in. (2.8 l.)
HORSEPOWER—S.A.E. or R.A.C.....	21.7
BRAKE (actual).....	25, at 2,000 r. p. m.
WATER CAPACITY	7.5 qts. (6.25 imp. qts.; 7.125 l.)
OIL CAPACITY—Engine.....	4 qts. (3.3 imp. qts.; 3.78 l.)
FUEL CAPACITY—All models.....	10 gal. (8.33 imp. gal.; 38 l.)
WHEELBASE.....	102" (2.59 m.)
TREAD.....	56" (1.42 m.)
ROAD CLEARANCE.....	9.75" (247. mm.)
TURNING RADIUS.....	20' (6.1 m.)
LOCATION OF NUMBERS.....	Plate on rear side of dash, under instrument board

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